The Cinematograph Book

Edited by
Bernard
E. Jones

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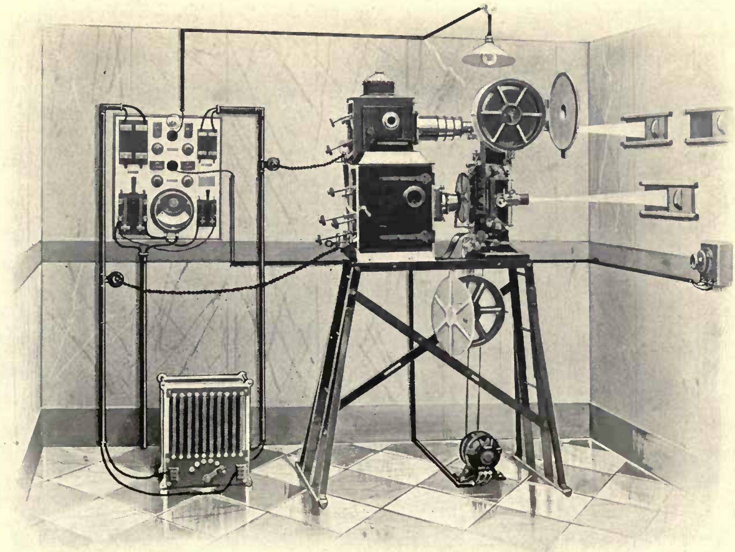

UP-TO-DATE PROJECTION OUTFIT
(Kinemacolor System)

The Cinematograph Book

A Complete Practical Guide to the Taking and Projecting of Cinematograph Pictures

EDITED BY

BERNARD E. JONES

Editor of "Work"

With 8 Half-tone Plates and Numerous Line Drawings in the Text

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PREFACE

This book provides a simple and easily understood guide to the art and practice of making and projecting cinematograph pictures. It fully explains the principle upon which the cinematograph effect is produced, gives detailed instructions on using a cinematograph camera and on developing, printing, and finishing the film, and then gives a course of lessons on the projector, embracing its mechanical and optical parts, illuminants and their management, its practical operation, cleaning, lubrication, etc., etc. In addition, chapters are included on what to do should the film fire, screens, film winders, trick films, home exhibitions, and cleaning and repairing films, the concluding feature being a reprint of the Cinematograph Act and of certain official rules, orders, and regulations.

I have much pleasure in acknowledging the help of Mr. A. Lockett, who contributes the instruction on practical cinematography, as well as on some other matters; of Mr. Theodore Browne, who is the author of the chapter on cinematograph pictures in natural colour and of parts of other chapters ; and of Mr. Phil Robinson, who is responsible for much of the information on practical projection. Some of the chapters are very largely from my own pen.

I appreciate highly the kindness of the many firms who have freely and courteously placed their illustrations and information at my disposal.

Readers in need of help on any subject dealt with in this book should address themselves to " Work," La Belle Sauvage, London, E.C., in whose columns—but not by post—their questions will be gladly answered.

B. E. J.

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THE CINEMATOGRAPH BOOK

CHAPTER I

Introduction: General Principles

THE optical illusion of "animated" or "moving" pictures is in accordance with a law relating to the persistence of vision of the human eye, whereby an image of a moving object does not instantly disappear, but is retained by the eye for a length of time depending on the intensity and colour of the light and the length of the period during which the eye was exposed to it. The knowledge of this fact is an ancient discovery, a reference to it being found in a book written by Lucretius about 65 B.C. One of the most familiar demonstrations of the phenomenon is the ring of colour or fire produced by whirling a coloured or burning stick; and other demonstrations are of everyday occurrence. A once popular toy—the wheel of life or zoëtrope—exhibited this principle in a convincing manner. Most people know this device (see Fig. 1)—an open cylinder with a number of viewing slits in its upper part, while arranged round the inside, below the slits, is a drawn or printed band of "motion" pictures which, as the zoëtrope revolves,

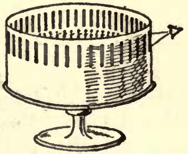


Fig. 1.—The Zoëtrope

combine to give the cinematographic effect. When the eye regards a moving object, certain nerves "telegraph" the impression to the brain, and the sensation may be divided into four periods: First, a latent period which is almost instantaneous, and during which nothing seems to happen; second, a period of less than $\frac{1}{100}$th of a second, during which the sensation reaches the maximum; third, a much longer period, $\frac{1}{30}$th to $\frac{1}{10}$th of a second, during which the sensation diminishes; and, fourth, a short period of decline, during which the effect dies away. When looking at a moving object the fourth period is unnoticed, because a new image takes the place of the old one at the end of the third period. Prof. Tyndall estimated the time of persistence of an impression on the retina to be $\frac{1}{16}$th of a second; in other words, the impression remains for $\frac{1}{16}$th of a second after the source of excitation is removed, and modern cinematography is based on this estimate, the pictures being both taken and projected at the approximate rate of sixteen per second.

The pictures are a series of photographic positives, printed by the action of light upon a continuous film or strip of celluloid coated on one side with sensitive emulsion; this film is of precisely the same nature as the universal hand camera film. To obtain the pictures in the first place, the film is exposed intermittently in a camera of special construction, next developed to form a negative, and a positive copy made from it by exposing it in contact with a new film to the light, and then developing as before. To exhibit the pictures, the positive film is passed through a special form of lantern which projects the pictures intermittently upon a screen. Sixteen pictures are made in the camera every second;

sixteen are projected by the lantern in the same period. In the camera, each picture receives an exposure of from, say, $\frac{1}{30}$th to $\frac{1}{100}$th of a second (the shorter the better, within reason, the light and special circumstances permitting), most of the rest of the time up to $\frac{1}{16}$th of a second being occupied in moving and stopping the film, since the film must be absolutely still for each new exposure. In the lantern or projector, each picture is projected on the screen for, say, $\frac{1}{24}$th of a second, most of the rest of the $\frac{1}{16}$th second, as before, being occupied by moving and stopping the film.

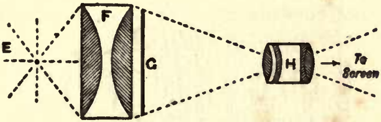


Fig. 2.—Optical Scheme of Lantern

Most readers are familiar more or less with the ordinary magic (or optical) lantern. As is generally known, it comprises a body, an illuminant, an optical system, and means for holding the transparency (slide) in the path of the light. The body may be of wood or metal. The illuminant E (Fig. 2)—oil lamp, incandescent gas, acetylene, limelight, or electric light—is supported by the body in line with the optical axis of the lenses, the lamp or jet being mounted on a metal plate or in a metal tray, which slides in grooves formed in the lantern body. The condenser F—two lenses mounted in a brass cell—collects the light rays and causes them to illuminate the transparency G evenly; thence the rays pass to the objective lens H (of the Petzval portrait type), which projects them upon the screen. Draw-tubes in the front of the lantern, and the rack and pinion on the jacket of the objective tube, afford a means of removing the objective lens farther from the slide, and thus allow of proper focusing. The transparency, carried in a wooden slide carrier having a to-and-fro movement, is inserted into the stage of the lantern immediately in front of the condenser, the carrier being held in place by a spring plate.

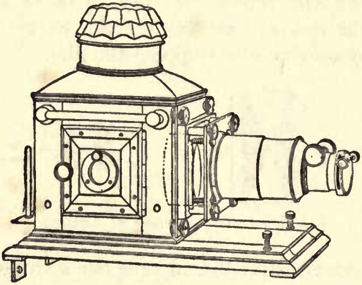


Fig. 3.—A Good Type of Optical Lantern

An excellent type of lantern which preceded the general introduction of the cinematograph is shown by Fig. 3, whilst on pp. 60 and 61 is shown a cinematograph projector complete. Comparison will show that the second is but a development of the first, the draw-tubes having been removed and a machine for accomplishing the intermittent movement of the film in the path of the light rays having been substituted. Thus the same optical principles apply to both, the distinctive difference between them being chiefly the relative positions of the slide and of the film in the path of the beam of light.

The optical lantern projects an image of a photographic transparency made on glass, which is held in a carrier and may remain several minutes in the path of the light, the projected image having a diameter generally from 30 to 80 times greater than that of the transparency or slide, and an area from 1,000 to 6,000 times as great.

In the cinematograph, on the other hand, a band of

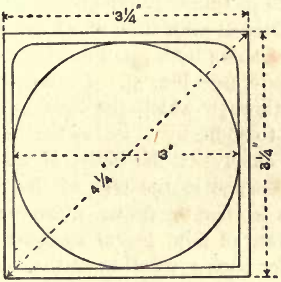


Fig. 4.—Lantern Slide

celluloid film, on which is a series of positive photographs, is unwound from a spool secured to the top of the machine, past the beam of light which is emitted from an aperture known as "the gate," and then wound on to another spool secured to the bottom. In this case the projected images, which rapidly follow each other on the screen, have each a diameter of from 80 to 200 times that of the pictures passing the gate, and an area of from 6,000 to 40,000 times as great.

When it is recognised how much greater is the magnification of the cinematograph image on the screen, as compared with that of an ordinary slide, the importance of using lenses of high magnifying power and of the best quality will be obvious.

An English lantern slide is $3\frac{1}{4}$ in. square, the aperture of the mask being generally 3 in., which is also the size of the picture (see Fig. 4).

The standard size of cinematograph film is $1\frac{3}{8}$ in. wide, $\frac{1}{200}$ in. thick, and it may be of any length up to 1,000 ft. or more ; each picture is $\frac{3}{4}$ in. high and 1 in. wide, and has four perforations at each side, which are regularly spaced and continued along both margins of the film throughout its entire length (see Fig. 5). The aperture of the gate or aperture through which the light is emitted is from $\frac{3}{4}$ in. by $\frac{7}{8}$ in. to $\frac{11}{16}$ in. by   in., so that a slight margin of the picture, chiefly at the sides, is always lost. The perforations engage in the pins of the sprocket wheels, and the film is thereby drawn downwards through the gate at the rate of 6 in. (equal to eight pictures to one movement) for each revolution of the handle.

Theoretically, the handle should be turned at the rate of two revolutions per second, which would bring 1 ft. of film, or sixteen pictures, into view during that time. This would be equivalent to 60 ft. in one minute, 120 ft. in two minutes, 1,200 ft. in twenty minutes, 3,600 ft. in one hour, and 5,280 ft. (one mile) in one hour and twenty-eight minutes.

Practically, however, the ratio of speed at which the film passes the gate will be found to be 50 ft. in one minute, 100 ft. in two minutes, 1,000 ft. in twenty minutes, 3,000 ft. in one hour, and 5,280 ft. (one mile) in one hour and forty-six minutes. The foregoing readily shows the approximate time which it will take to show a film of a certain length.

From what has already been said, it may appear that the taking, and especially the projection, of cinematograph pictures is a simple matter. But a little study of the subject will show that though the principles of the processes and operations required are easily grasped, the complications in practice are so many that the competent cinematograph photographer needs to be an exceptionally skilled man, whilst the projector operator is certain to meet trouble unless he is thoroughly conversant with the optical and mechanical principles of his machine and

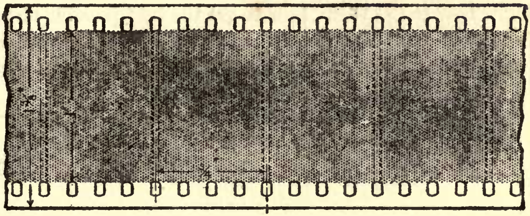


Fig. 5.—Cinematograph Film

the uses of the accessory appliances, and also unless he has at least some elementary knowledge of electricity and can handle ordinary tools with some degree of proficiency.

The duties of the cinematograph lanternist are considerably more difficult and more responsible than in the old days when a magic-lantern exhibition consisted of "still" pictures, a few comic slipping slides and revolving chromatropes, with a three- or four-wick paraffin lamp as the illuminant. Even then there were sometimes failures on the part of the exhibitor. The work grew more complicated when limelight became general; and as the magic lantern, with its paraffin lamp, gradually evolved into the optical lantern, single, biunial, and triple, with its high-pressure limelight jets, gauges, regulators, etc., so the exhibitor had to become more or less trained in the principles of scientific projection, if a successful show was to be assured. It is becoming increasingly obvious that the high-grade operator should be specially trained, not only in the art of the scientific projection of " still " and " motion " pictures—he must also have a knowledge of the mechanism and the uses of the various apparatus that are placed under his care. And, further, he must know how to use them, how to get the best possible results from them, and how to act in any unforeseen accident and emergency. The safety of his audience is in his keeping.

CHAPTER II

Some Historical Notes

THERE can be no doubt that the real inventor of motion photographs was Eadweard Muybridge, who was born at Kingston-on-Thames in 1830, and afterwards migrated to America. In 1872, whilst in charge of the General Photographic Survey of the Pacific Coast in California, he first interested himself in "moving" pictures. After many experiments, he succeeded in giving the first exhibit in 1879, when limelight was used for projection. After touring throughout the States, he came to Europe, and gave an exhibition at the Royal Institution, in London, on March 13th, 1882. Mr. Muybridge lived to see wonderful improvements in the projection of motion pictures. He died in 1904, and was buried in his native town, leaving all his works and mechanism to the Royal Borough of Kingston-on-Thames, where they may be seen at the Public Library.

The first cinematograph using a continuous photographic film was patented on June 21st, 1889, by W. Friese-Greene and M. Evans, and was exhibited before the Bath Photographic Society on February 25th, 1890. The camera made three hundred exposures at the rate of ten exposures per second. The film passed from a feeding spool over a plate which held the film flat during exposure, and was received and rewound on a second spool, both being driven at an equal rate from a main shaft.

Between the light aperture and the receiving spool a roller containing a spring was interposed, the roller being continually wound from the main shaft. This spring would have caused the roller to revolve as fast as it was wound, but on the edge of the roller was fixed an escapement tooth, which rested against a cam. The cam, itself constantly revolving, arrested the motion of the roller, but a gap in its edge permitted the escapement tooth to pass once in every revolution. Each time this happened the roller made one turn, and drew down the exposed part of the film, substituting a fresh portion. While the film was stationary, the portion that had just passed down was being rolled up on the receiving spool, and the feeding spool was reeling off a sufficient length of fresh film ready to be carried down by the roller for the next exposure. During the movement of the film, the exposure opening was covered by an intermittent shutter. The arrangement for projecting the positive film was on practically the same principle.

In America, T. A. Edison was first with his kinetoscope (U.S. patent, March 14th, 1893). This was exhibited at the Brooklyn Institute on May 9th, 1893, and was intended to be viewed by one person at a time, looking through an eye aperture. A perforated celluloid film was used, at first with a single line of perforations only. The present standard Edison gauge film, with four holes on both sides of each picture, was introduced a little later, the exact date being uncertain. The film moved without stoppage, light being allowed to pass momentarily each time a picture was centred, by means of a one-slot circular shutter driven at the rate of forty-six revolutions per second. Soon, however, a projecting pattern was made, in which an intermittent motion was given to the film by the interaction of a star-wheel and pin. In France, G. Demeney was first with the chrono-photographe, patented in that country October, 1893, and in England December 19th of the same year. In this, the film was intermittently struck by a revolving eccentric or dog.

The biograph was the name given to an early machine (1896) invented by Herman Casler, of Canastota, New York, U.S.A., who considered that better results would be obtained if the film pictures were larger than the usual 1 in. by $\frac{3}{4}$ in. scale. He devised the biograph to take pictures measuring $2\frac{5}{8}$ in. by $2\frac{1}{16}$ in. and to utilise the whole surface of the film, dispensing with side perforations, by the introduction of an arrangement of rollers instead of sprocket wheels. The biograph projected pictures at the rate of thirty to forty per second, and flickering was thus largely overcome. Further, Casler claimed that inasmuch as the film was carried forward by friction rollers instead of by sprocket teeth, there was greater steadiness of the images upon the screen. The biograph enjoyed a season of popularity, but it failed to become universal.

The name "bioscope" was first applied to the cinematograph, it is commonly stated, by Charles Urban, and has now become general. It is believed to be derived from two words meaning "life" and "to see."

A fact that has been generally overlooked is that the term "bioscope" is the name of an invention by Eugène Simmonar, probably introduced late in the 'seventies of the nineteenth century. This invention was a portrait, in which the eyes of the person photographed appeared sometimes open and sometimes closed. In producing this illusion, two photographs of the sitter were taken, one with the eyes open and one with the eyes shut, and one of these was reversed right to left. Probably a piece of paper was sensitised on both sides, and one photograph printed on one side and one on the other, so that when held up to the light they were in perfect register. There was an arrangement by which the photograph could be lighted from either the back or front, the eyes appearing open by the one light and closed by the other. By rapidly alternating the lighting the illusion of winking was obtained.

The word " cinematograph " (more correctly, " kinematograph ") is derived from the Greek *kinema*, meaning motion, and the Greek *grapho*, to write or describe.

Not all cinematograph machines, it may here be said, employ a continuous strip of film. For example, in the apparatus invented by Leo Kamm, a circular glass plate, 12 in. in diameter, is used as a support for the sensitive emulsion, at its centre being a hole about 1½ in. in diameter, and the mechanism is such that the plate cannot race past the point at which it is required to be held momentarily stationary for purposes of exposure. The circular plate is given an intermittent rotary motion and also an horizontal displacement, which enables a series of pictures to be impressed upon it in a spiral form. The combined camera and projector is made in two patterns, both of the same size, but one taking 350 and the other 550 pictures on the disc. Each picture of the 550 series measures ¼ in. by $\frac{5}{16}$ in., while those of the 350 series are slightly larger. There seems no likelihood of this system ever proving a serious rival to the film.

CHAPTER III

The Cinematograph Camera and How To Use It

THIS chapter deals with the selection and use of a cinematograph camera, together with the various operations involved in making negative films and in printing positives for projection.

The Camera Described.—In principle the motion-picture camera is very similar to the projector—in fact, many projectors could be used as cameras if they were boxed in to exclude stray light. It differs, however, in some respects. For example, undue heaviness can be avoided, since fireproof construction is unnecessary, while the accessories with which it is fitted are of a distinctively photographic nature. It will be useful to recapitulate the essentials that have to be met. Firstly, a series of photographs has to be taken in rapid succession with an exposure brief enough to show no excessive movement blur in any of them; secondly, in order to do this in one continuous length, the film has to be kept steady in front of a lens during each exposure and then moved onward abruptly to bring into position another space of unexposed film; and, thirdly, a shutter must alternately uncover and obscure the lens to coincide exactly with these periods of rest and of movement.

The usual internal arrangements of a modern cinematograph camera are illustrated by Fig. 6, though the exact details vary with the make. The unexposed film is contained on a spool A, the end being threaded under a guide roller B and under a wheel C furnished with sprockets or projections which engage in the perforations at each side of the film. A spring roller D keeps the film against the sprocket-wheel and prevents it from slipping. At E is the gate or trap, in which is the exposure opening, or mask.

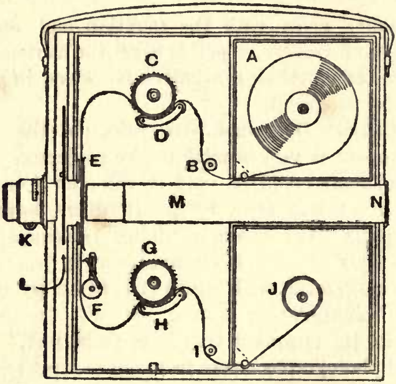


Fig. 6.—Mechanism of Cinematograph Camera

The gate is in two parts, one fixed and the other capable of swinging or lifting slightly, but normally secured by springs or a catch. The function of the gate is to keep the film flat and steady during exposure. At F is the intermittent mechanism, which pulls the film down space by space as fast as it is supplied by the upper sprocket-wheel, by means of pins or claws, alternately inserted in and withdrawn from the perforations. Below this, the film passes under a second sprocket-wheel G, also furnished with a spring roller H, under the guide roller I, and is then rolled up on the winding-off spool J. Behind the lens K is a rotary shutter L, geared to stop the passage of light during the downward movement of the film, but to leave the lens uncovered for an exposure whenever the film is at rest in the gate. A finder is provided for focusing purposes, consisting of a long narrow tube M running right across the camera and having a cap N

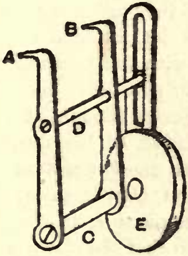


Fig. 7.—Pin or Claw Movement

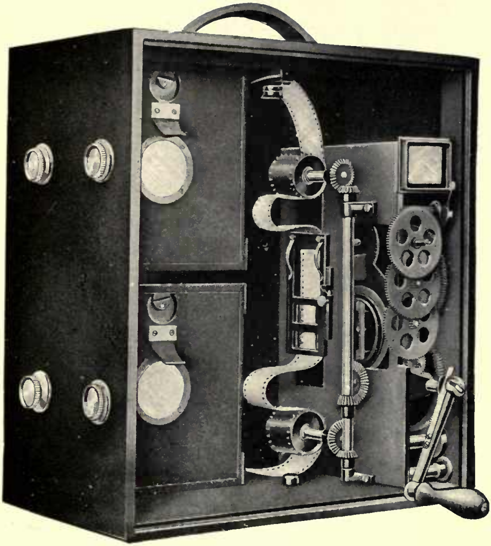
Fig. 8.—Williamson Claw Movement

outside. On removing the cap and looking through the tube, the image thrown by the lens is seen on the film itself, framed in the gate. The focusing tube may, or may not, have a magnifying lens, which also shows the image the right way up. The objective lens K focuses by means of a rack and pinion on the mount, or by turning a milled ring. For keeping the subject in view during exposure, when, of course, the cap has to be placed on the tube, an extra finder is commonly fitted outside the camera. This may be either a concave lens, an open wire frame with a sight, or of the box type, resembling a miniature camera. The spools of film are carried in interchangeable light-tight boxes taking the place of the ordinary dark-slide.

The Claw Movement.—One form of the intermittent pin or claw movement is shown by Fig. 7. A pair of claws A and B are connected by bars C and D, forming a frame which is pivoted near the margin of a disc E. The bar D projects and works in a vertical slot F. As the disc E revolves, the claws are given an eccentric up-and-down motion, while since they are also guided by the movement of the bar D in the slot, a to-and-fro action is imparted in addition. Thus, with the rotation of the disc, the claws approach the film, pull down one picture space, and then are withdrawn, leaving the film at rest for exposure, until a further revolution of the disc again advances the claws and pulls down another picture space. Fig. 8 illustrates the Williamson claw movement, in which a central guide or bridge-piece A is employed, having a slot of a special curve, so that the claws proceed in a D-shaped path, as indicated by the dotted lines.

The Shutter.—The shutter, like the pin escapement, has normally to make sixteen revolutions per second, which is equivalent to sixteen pictures or one foot of film. Since the mechanical speed of the shutter cannot well be altered, save by modifying the rate of turning, the only way of varying the duration of exposure is to increase or reduce the size of the opening. The whole mechanism is actuated by a train of gear-wheels operated by a handle on the left-hand side of the camera, which is usually turned twice in a second.

Other Fittings.—Among what may be called refinements, seen only, as a rule, on the medium-priced



INTERIOR OF TYPICAL CINEMATOGRAPH CAMERA
(*Pathé Frères type*)

and the higher-grade apparatus, may be mentioned the measurer, which registers on an outside dial how many feet of film have been exposed ; the film punch, for making a mark or hole at the end of an exposure, to show, when developing, where one subject finishes and another begins ; and the speed indicator, to show the rate at which the handle is being turned. In cameras intended to be used for trick photography, two extra spindles for attaching the handle are commonly provided, one working the film backwards and the other exposing only a single picture to each turn, for use when a specially slow movement is wanted. Fig. 9 illustrates a typical high-grade camera on a tripod having a rotating head and tilting table. The dial of the measurer will be noted at the top.

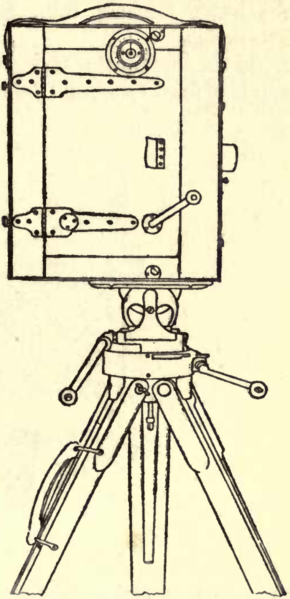


Fig. 9.—Professional Camera on Tripod (Gaumont Type)

Variety of Cameras Obtainable.—The amateur, or those who wish to take only an occasional film of a length not exceeding about 120 ft., may obtain for a relatively moderate price what is known as a one-sprocket topical camera. This will usually have a first-class lens and should be capable of doing ordinary work, but will probably have a shutter with fixed aperture and will lack the inside focusing tube, film-measurer and such-like accessories.

In the cheaper cinematograph cameras of this type the lens is of fixed focus, and the subject can only be seen in an

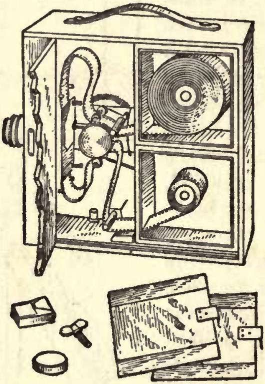


Fig. 10.—Butcher's Empire Camera

external view-finder. At a slightly higher price a lens with a focusing ring, and having a distance scale engraved on the mount, is obtainable, and it may also be possible to examine the focus critically, if desired, by opening the camera door before threading the film and inserting a piece of plain matt celluloid in the gate. Fig. 10 illustrates the interior of a typical one-sprocket camera. It will be noted that the single sprocket has two spring rollers above and below it respectively, and serves both for supplying the film and for passing it to the take-up box after exposure.

At least one daylight-loading topical camera is on the market. The film is obtainable on metal spools with about 5 ft. of black paper wrapping at each end, thus allowing it to be loaded into or removed from the camera in full daylight.

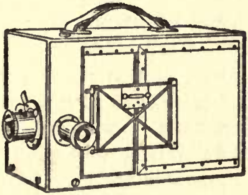


Fig. 11.—Reflex Cinematograph Camera

Apparatus of special construction may now be considered.

Fig. 11 above shows a camera on the reflex principle, which is in many ways unique. By placing the film-boxes side by side, instead of above each other, space is economised, while yet 400 ft. of film is accommodated. A small mirror is mounted inside at an angle of 45° to the lens axis, and when brought into position the exact picture may be seen and focused through a magnifier at the side. The mirror may then be immediately raised and the exposure started. A wire-frame direct-vision finder, shown folded down, is fitted in addition. Interchangeable lenses of from 2 in. to 10 in. focus can be used at will.

Hand-camera cinematography has been rendered possible by means of the Aeroscope apparatus, invented by Casimir de Proszynski. With this there is no handle to turn, the driving being done by a compressed-air motor charged up with an ordinary bicycle pump. Freedom from oscillation while held in the hand is ingeniously secured by an enclosed gyroscope. This camera is well adapted for impromptu topical work, for films illustrating travel, and for natural history records.

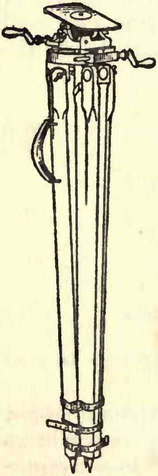


Fig. 12.—Kineto Camera Stand

For professional motion-picture taking, a specially strong rigid stand is needed, but with a small one-sprocket camera any substantial tripod used for taking still photographs will do, provided the head has no looseness or side-shake.

Even for the amateur's use, however, one of the proper cinematograph-camera stands is strongly advised. These may be purchased at prices to suit all pockets, either with a plain top or with a revolving panoramic head. Fig. 12 shows, closed for carrying, a typical professional stand with revolving and tilting movements, worked respectively by the two handles shown at the sides. These adjustments are often very useful, as not only do they save trouble when training the camera on the average subject, but, if desired, a circular panoramic view can be taken from a raised position with the apparatus tilted at an angle, or the evolutions of aviators, etc., may be followed throughout. The latter class of work naturally requires two operators, one to make the exposure and the other to manipulate the handles of the tripod head and to keep the subject in the finder. The cinematograph tripod is usually made to extend to 6 ft. or more for convenience in operating above the heads of a crowd.

The Film.—Unexposed perforated film, both negative and positive, is supplied in rolls packed in sealed metal boxes. The price varies with different makes, but the average may be put at 2½d. per foot for the ordinary celluloid or 3d. per foot for "non-flam." Like plates, films are made in different speeds, extra rapidity being sometimes valuable for work in a poor light, in interiors, or with quickly moving subjects. Positive film is slower than that used for negatives, and the celluloid is a trifle thicker, since it is called on to do longer and more vigorous service. Workers on a large scale often prefer to purchase unperforated film and do their own perforating, for which purpose a special machine is needed.

The method of manufacturing film may here receive brief attention. Film is composed of celluloid, which is first manufactured from pure bleached cotton fibre (cellulose, $C_6H_{10}O_5$), by nitrating it with a mixture of nitric and sulphuric acids, thus forming pyroxylin, which is intimately associated with gun-cotton. This is bleached by the aid of permanganate of potash, or by chlorinated lime. The pyroxylin is then rendered plastic by treatment with a mixture of alcohol, ether, acetone, amyl acetate, and camphor, until the mass becomes homogeneous, and is then formed into large sheets. These are piled up until a sufficient quantity is obtained, and then welded into a solid block by hydraulic pressure. The block of celluloid thus obtained is dried and cut up into the size and shape required. For sheets, the block is rapidly cut to the desired thickness by a planing machine. The sheets are then dried and cut into strips of the width required for use. The plain film is then coated with sensitised gelatine emulsion and perforated ready for exposure in the camera.

CHAPTER IV

Taking Cinematograph Pictures

Loading the Camera.—To load the empty film-box, it is taken into the dark-room, together with a tin of unexposed film. Having made sure that all white light is excluded, only a dull ruby light being present, the film-box door is opened or the lid removed, as the case may be. The tin of film is then unfastened, the wrappings removed, and the roll lifted out. Care must be taken not to let it unwind, except for about 3 in. at the outer end. At one corner of the film-box will be noticed a narrow slit A (Fig. 13) trapped with velvet, against which, inside the box, is a small roller B running in a recess, which serves to prevent any light getting in through the slit. When loading, the slit should be at the left-hand bottom corner, as shown, and the roll of film, having its free end on the right-hand side, is placed over the wooden hub C on the spindle in the middle of the box. The film should on no account be secured to the spring on the hub. The loose end of the film is next passed

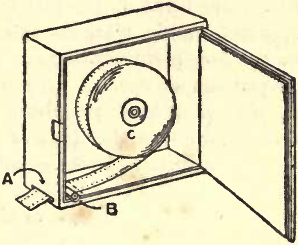


Fig. 13.—Method of Loading Camera Film-box

under the roller and through the slit, leaving about 2 in. protruding outside, the door of the film-box being then shut and fastened.

The loaded box may now be taken from the dark-room and inserted in the upper part of the camera, first pulling out the protruding film for a length of about 18 in. This portion is, of course, unavoidably fogged. The box should be placed so that the slit is at the lower left-hand corner. Threading through the camera mechanism is usually carried out as shown by Fig. 6, or as in Fig. 10 if there is only a single sprocket; details, however, vary somewhat in different apparatus. The spring rollers are lifted as the film is passed over or under the sprocket-wheels, allowing them to return again as soon as the film perforations have engaged properly with the projections or teeth. Care must be taken to leave a short loop, at least 3 in., both above and below the gate, and to note that the claws of the pin escapement engage the perforations. If these points are neglected the film may be damaged or broken. After threading, the film is passed through the slit at the left-hand bottom corner of the lower or take-up film-box, under the recessed roller, and to the empty hub on the spindle, this time securing the end of the film under the spring clip on the hub.

The camera handle is now slowly turned till the film has wound once or twice on the hub, in order to see that all is working properly, after which the door or lid of the take-up film-box is closed and fastened and the camera door also secured. All is then ready for operating.

When much work is expected, it is usual to carry several extra loaded film-boxes, which, being interchangeable, can be used in succession for taking-up as they are emptied. It will be noted that the spindles in the film-boxes are connected to an external rotating brass plate having two studs, and that, in the case of the take-up box, a driving gearing engages with these studs, a friction clutch being provided to allow of slip, in order to accommodate the speed of rewinding to the gradually increasing diameter of the roll of film.

Using the Camera.—The manner of starting work depends a good deal on the subject. If a scenic one, it is possible to choose the time when the view or landscape will be pleasingly lit. As a general rule, this will be when the sun, whether obscured by clouds or otherwise, is on one side of the camera and a little behind it. When there is a wide choice of position, the most effective lighting can probably be obtained merely by careful selection of standpoint, but, more frequently, there is found to be only one ideal spot at which to set up the camera if the prospect is to be taken at its best, and in such circumstances the operator will have to estimate when the sun will be in the right quarter and postpone the exposure till then. Some of the most successful scenic films have only been made as the result of several previous visits to note down satisfactory positions for the camera and approximate times for exposing. A scenic subject is suggested as a good one for the novice, because the work will be more like ordinary photography, and there will be no embarrassment from the necessity of following energetic action. Naturally there should be movement of some kind, or the film would simply be thrown away. Country and farmyard scenes, river pictures with rippling reflections, seascapes with breaking waves and possibly shipping, are within this category.

The first thing to do is to erect the stand, planting it firmly where it cannot slip or vibrate. The camera is then screwed on top and the lens is directed towards the subject, opening it to the largest stop by turning the ring or projection on the iris diaphragm. The cap is removed from the finder tube, and, looking through this from the back, with one hand on the lens, the picture is focused as sharply as possible on the film in the gate by slowly moving the milled head of the pinion, or rotating the focusing ring if that is fitted instead. If the shutter is not in the open position turn the handle very slightly until it is. If preferred, a piece of plain matt celluloid, on which the image is more readily seen, may be inserted in the gate before threading the film, and the focusing done upon this instead.

Should it be thought that a little shifting to right or left will give a better composition, this may be attained by working the panoramic head, or, in its absence, by loosening the screw and moving the camera with the hand, taking care to tighten the screw again. When the subject is somewhat too high up or too low down on the film, the camera may be tilted a trifle downward or upward, as the case may be, unless buildings or objects having vertical lines are present, when the alteration should be made by raising or lowering the stand, or by choosing a different viewpoint, since tilting the camera causes convergence of upright lines. Some cinematograph cameras have a rising and falling lens board, with which a slight adjustment is obtainable without shifting the apparatus.

Use of the Lens Stop.—Having got the subject satisfactorily arranged on the film and sharply focused, the stop to use must be decided upon. The purpose of the stop or diaphragm is, firstly, to secure greater equality of focus between distant and near objects occurring in the same picture, and, secondly, to enable the exposure to be varied by regulating the amount of light that passes to the film. Now, as a rule, short-focus lenses are used on cinematograph cameras, and these possess, in an unusual degree, what is known as depth of definition, which means that, even with the largest stop, the near objects and the far-off ones will be almost equally sharp. Consequently, there is comparatively little need, save for some special purposes, to use a small stop in order to secure generally good definition. This is obviously an advantage on occasions when the light is dull.

In a bright light, however, the film would be overexposed unless either the lens is stopped-down or the shutter aperture decreased. For an average outdoor subject in a decent summer light, a stop of *f*/8 is usually about correct, in conjunction with a shutter aperture of 120°, or one-third of a circle. On a winter afternoon *f*/3·5 will not be too large; while, going to the other extreme, with a brilliant seascape the lens may need stopping-down to *f*/16 or more.

There are disadvantages as well as advantages both in using a small diaphragm and in closing up the shutter. Suppose the subject is a landscape having a river with waving bulrushes in the foreground and hills in the distance. The river and bulrushes should be focused as sharply as possible, and if this is done with a large stop the hills will be pleasingly soft in outline and will really look far off. If, now, the lens is stopped down to any extent, the hills will become as sharp as the foreground and much of the beauty of perspective, together with any effect of relief or of atmosphere, will be lost. In such circumstances, it is better to cut down light, if necessary, by narrowing the shutter opening than by using a small stop.

The majority of British lenses are marked on what is known as the *f* system, whereby the diameter of the beam of light admitted by any stop is divided into the focal length of the lens and the quotient is called the *f* number of that particular diaphragm. Thus, supposing a lens is of 3 in. focus and its largest stop permits the entrance of a beam of light $\frac{1}{2}$ in. in diameter; then, since $3 \div \frac{1}{2} = 6$, the diaphragm is marked *f*/6. The front glass of the objective condenses the light a little before it reaches the stop, so that the true *f* value is not necessarily obtained by merely measuring the diameter of the latter. In opticians' catalogues lenses are always listed at their largest aperture.

Lens "Rapidity" and Exposure.—Theoretically, any two lenses having the same aperture will be of identical "rapidity," that is to say, they will admit the same amount of light and will allow of similar exposures. Practically, something depends on the number of glasses, reflecting surfaces and air spaces in the lenses compared, or even on the different kinds of glass used in their construction. Thus a triplet lens, having three combinations, commonly proves a trifle slower than a doublet, which has only two; while glass of a dark colour or yellowed by exposure may markedly decrease the light.

Obviously, the larger the stop in relation to the focal length of the lens, the more light is admitted and the shorter may be the exposure. The rule is, that the exposure increases or decreases as the square of the *f* number. Thus, take *f*/4, the square of which is 16, and *f*/8, the square of which is 64. Since 16 is one-quarter of 64, *f*/4 requires only one-fourth the exposure of *f*/8. This is readily understood if it is remembered that *f*/4 is twice the diameter of *f*/8, and that its opening must therefore be of four times the area. The stops are usually marked so that each succeeding higher *f* number needs double the exposure of that immediately preceding it, though the largest aperture is sometimes an exception.

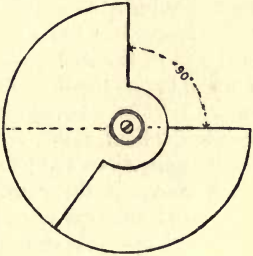


Fig. 14.—Adjustment of Camera Shutter

High-class cinematograph lenses are of the anastigmat type, giving good definition and a flat field at a large aperture, usually *f*/3·5, *f*/4, *f*/5.6, or thereabouts. Mention must not be omitted of Dallmeyer's *f*/1·9 objective, with which the exposure is less than one-quarter of that needed with *f*/4, and it becomes possible to do satisfactory work in a poor light or late in the day.

Shutter Speeds.—The shutter factor may now be considered. Since, normally, the film is run through the camera at the rate of sixteen pictures per second, while the shutter revolves once to each picture, it is clear that every revolution occupies $\frac{1}{16}$th of a second. If, then, the shutter sectors are adjusted so that the opening is 90°, or one-quarter of a circle, as in Fig. 14, the time during which light is allowed to pass to the film is only one-quarter of $\frac{1}{16}$ sec., or $\frac{1}{64}$ sec. If the opening is one-third of a circle, the duration of exposure is $\frac{1}{48}$ sec.; if it is one-half of a circle, the exposure is $\frac{1}{32}$ sec., and so on.

The shutter speed required depends on two things; first, the amount of light necessary to make the exposure, and, secondly, the rapidity with which moving objects pass before the lens. With regard to the latter, take such a subject as a galloping horse. With this, if the shutter speed is too slow, movement-blur will be conspicuous in the film pictures; whereas, with a leisurely drifting barge, the slowest speed would be quite sufficient unless it should be preferred to increase it in order to reduce the light, rather than lose breadth and perspective by stopping-down the lens.

A study of the correct shutter speeds for objects moving at different velocities is highly important to the motion-picture operator, but it will not do to accept the figures given for ordinary photographic work, because the conditions are by no means similar. Suppose a single glass-plate negative has to be taken of a cycle race, crossing directly in front of the camera at about 25 ft. distance. According to the usual tables, to avoid showing movement-blur the exposure should be $\frac{1}{900}$ sec. Now, if it were attempted to use such a speed with a cinematograph camera, for the same subject, undoubtedly each separate film picture would be sharp, but when projected on the screen the figures would move jerkily, and there would probably be multiple overlapping outlines. The reason is that, since the exposures are made at a regular rate of sixteen per second, shortening them unduly means a longer interval between any two pictures, during which a rapidly moving object has time to assume an appreciably different position, while the intermediate stages between these two phases of movement are not adequately represented. It is better, therefore, to use a medium-speed shutter, not exceeding, say, one-quarter of a circle, or $\frac{1}{64}$ sec., and to tolerate a certain amount of movement-blur in the individual pictures, since these will then blend into each other better during projection, and the effect will be more realistic. It must be remembered that the eye does not really see quickly moving objects as sharply as they would need to be defined in a single stationary photograph, such as a newspaper illustration.

Fig. 15.—Watkins Exposure Meter

Using an Exposure Meter.—The light is a very variable factor, and its actinic or photographic value can only be properly estimated by employing an exposure meter. A meter specially scaled for cinematography is made by the Watkins Meter Company, Hereford, and is obtainable from most photographic dealers. As illustrated by Fig. 15, it resembles a watch, and is furnished with a chain having a ball at the end. This is used as a pendulum for counting seconds and half-seconds. Near the margin will be noted a small semicircular opening, by the side of which is the remaining half-circle, painted a greyish colour. Inside, behind the opening, the sensitive paper is placed, a fresh portion being brought into position by rotating the back of the case. Round the edge of the meter are scales marked " Act." and " Exp.," signifying respectively Actinometer Time and Exposure; while round the inner movable dial are scales relating to Film Speed and Stop. To use, a fresh portion of sensitive paper is brought into position and instantly covered with the finger. The pendulum is then started swinging and the finger is removed, commencing to count at the same moment. Directly the paper darkens to the shade of the standard tint, counting is stopped. The film speed is then set against the time occupied in darkening, or Actinometer Time, by gripping the glass against the back and rotating both simultaneously, when against the shutter speed will be found the stop advisable. The meter should be held so that the same light falls upon it as upon the subject to be photographed.

Actual Operation.—Assuming everything is ready for exposure, the operator starts turning the handle, in the same direction as the hands move round a clock. This must be done steadily and evenly, at the rate of two turns per second. It will be as well to practise turning beforehand with an empty camera, using a watch having a seconds hand as a guide to the rate of turning, unless, of course, the camera has a speed indicator.

The operator should form, if possible, a rough idea of how much film he wishes to expose on a particular subject. If the whole spool, there is nothing to do but continue turning until the handle suddenly runs easier, thus showing that all the film is through; whereas, if only a portion of the spool is wanted, the outside measurer must be watched and the turning stopped directly the desired figure is recorded. It is usual to indicate the end of the exposure in such a case, either by operating a punching device or by opening the camera and nicking a small piece out of the edge of the film with a scissors. During operating an eye must be kept on the subject, to see that everything continues right and that no person or obstruction gets in the way.

"Topicals."—Something may here be said about topicals, or "newsy" films, including such things as processions, pageants, reviews, athletic displays, opening ceremonies, cricket or football matches, and so on. Quite the most important consideration with such subjects is the selection of a good standpoint. Sometimes this may be arranged beforehand by application in the right quarter, or by making friends with officials, but more often the operator has to put up with the best he can get and to take his chance with the public. The only advice that can be given is to come reasonably early, to keep on good terms with the crowd or with rival operators, and to accommodate oneself readily to any requests made by the police or others in authority. Pliability and a conciliatory attitude in the last respect often leads to special facilities being offered, whereas the contrary spirit may raise up unexpected obstacles. A standpoint slightly elevated, so as to be above the heads of the people, is desirable, though occasionally it is better still if one can get right in front. When need arises, additional height may be got by fully extending the tripod legs, standing on a box or other convenient support to operate. Possibly the camera case will have been made strong enough to serve.

As far as possible, the distance should be judged at which the pageant, procession, or whatever it may be, will pass or take place. The camera should then be focused upon that distance, or the lens set to it by means of the scale which is, or ought to be, provided. For most topical subjects not actually close to the camera and in a fairly good light, so that an unusually large stop is not needed, it will be about right to set the lens scale to a distance of 100 ft. When the subject comes in sight, the camera is promptly pointed in the right direction by means of the tripod adjustments, the handle being instantly started and the object of interest kept in the picture by watching the outside finder and working the turntable if necessary. When a long procession or pageant is filmed, it is seldom that the whole of it is taken, unless of exceptional public attraction and warranting the expenditure of so much film. It is more usual to expose only on the principal features or most striking portions, stopping the handle when one of these has passed and starting it again when the next appears. The sections of the film should not, however, be made too short and abrupt.

If the film is to be disposed of, what follows must be done quickly. Preparations should previously have been made for its prompt reception, development and printing, and the speediest way back should have been ascertained. Nowadays, if a topical film is to have much value, it has to be showing publicly on the screen within the briefest possible time after the actual event.

Staged Subjects and Story Pictures.—These are scarcely within the scope of the amateur or the worker on a small scale. Except for such incidents as can be acted suitably in outdoor surroundings, a well-lighted studio with ample room is indispensable. This should preferably be on the top of a house or, at least, in open surroundings. There should be liberal glazing for the admission of daylight, while, unless the work is to be hindered by time and weather, an adequate installation of mercury-vapour or arc lamps is also required. The scenery and accessories are much the same as for the ordinary theatre, save that backgrounds, etc., may be in monochrome instead of colour. Usually professional artistes are engaged for the different parts. The larger film-producers keep stock companies, including a certain number of "stars," but smaller firms, or those who only go in for an occasional staged subject, are content to secure the spare-time services of a few averagely good performers from a local theatre. The conditions for good film-acting are somewhat different from those obtaining on the ordinary stage. Since words are practically lost, gesture and expression become of primary importance, but these should not be exaggerated, except in farcical or comic films. The part should be spoken as well as acted, however, though the wording may be more or less impromptu, in order to get a natural effect; and special distinctness of enunciation is desirable at all dramatic moments, as it much improves the realism of the film if the public can gather a few key exclamations or sentences by watching the movements of the mouth. Care must be taken that the actors keep within the field of view of the lens and make their exits properly outside it. As an aid to this, it is advisable to draw two diverging chalk lines on the floor from the position of the camera to indicate the space within which all action must take place. Careful planning and repeated rehearsal are always necessary, to secure that everything shall be done in the minimum time, in order to avoid waste of film.

CHAPTER V

Developing Films

The Developing Frame.—To develop an exposed film it must first be wound on a frame—of course, in a "safe" light. The kind of frame now mostly used by professional workers is known as the flat frame, and is illustrated by Fig. 16. It is generally of teak, with a row of projecting brass pegs at top and bottom to prevent the film overlapping. Metal standards screwed to the floor, as shown, are commonly employed when winding, in conjunction with a rod from which the frame is readily detachable, though some workers prefer a substantial wooden stand.

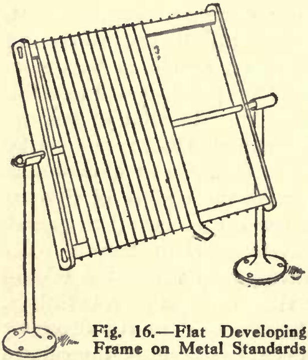
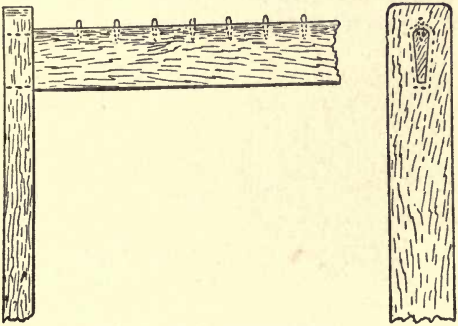


Fig. 16.—Flat Developing Frame on Metal Standards

Such a frame is quite easy to make. Fig. 17 shows in elevation, and Fig. 18 in section, the details of construction. The sides are thicker than the ends, in order to keep the film from touching the dish, while the top and bottom bars are rounded on the outer edges and slope inward. Well-smoothed headless brass nails, placed about 1½ in. apart and projecting about ¼ in., will do for pegs. A frame 33 in. square outside will accommodate 100 ft. of film.

To wind, the end of the film, gelatine or emulsion side outward, is secured to the top bar by a drawing-pin, and the frame is then revolved slowly away from the operator,



Figs. 17 and 18.—Home-made Developing Frame

at the same time guiding the film into position between the pegs as it unrolls and winds over the bars. It should be wound rather tightly, though without actual strain, as it expands when wet.

The Pin Frame.—The pin frame (Fig. 19) is generally of brass, with diagonal rows of pegs about 1½ in. high. To wind, a small loop is made at the end of the film and secured by an ordinary steel pin. The loop is then slipped over the innermost pin on the frame, and the film is wound spirally round all the remaining pins in turn, as shown by the dotted lines, emulsion side outwards, fastening the outer end by making a second loop. A pin frame has the advantage of occupying less space for a given length of film than the flat pattern, and therefore needing smaller troughs or dishes, with correspondingly less solution, but the winding takes longer and requires greater care.

Troughs and Tanks.—Development is done either in flat stoneware troughs, as illustrated by Fig. 20, or,

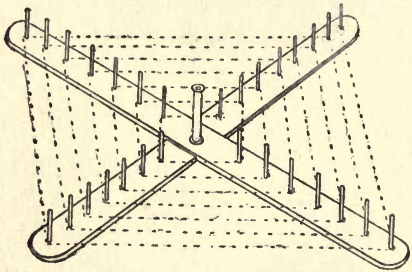


Fig. 19.—Winding a Pin Frame

when a number of frames have to be dealt with at once, in upright tanks having grooves or divisions. A close-fitting lid or cover is advisable, to prevent oxidation of the developer. For the amateur a flat trough or dish is most convenient. A home-made wooden tray about 4 in. deep, lined with linoleum or varnished to render it waterproof, is quite serviceable.

On a small scale, at least three dishes or troughs will be needed—for developing, fixing, and rinsing or washing; though when only an occasional film is wanted it is certainly possible to manage with two, if the fixing solution is kept handy in a large jar or tub. Where much work is done, however, a vertical trough with divisions to take several frames at once would be used for fixing, while washing would be carried out in an upright tank, lined with galvanised iron or lead, having a siphon and air-cock in addition to a draw-off tap, as illustrated by Fig. 21.

The Developer.—The quantity of developer required

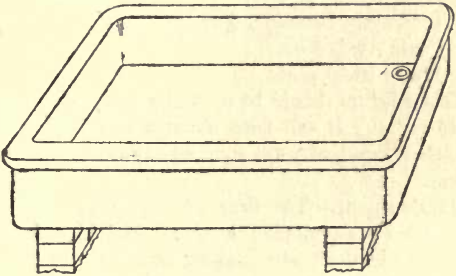


Fig. 20.—Stoneware Developing Trough

depends on the size of the dish or tank, and must be sufficient to cover the film completely and for at least ½ in. above the top edge. It is easily ascertained by noting how many quart jugs of water are necessary to fill the respective receptacles to the proper level. As a rough guide, a trough 35 in. square filled to 2 in. deep holds 68 pints. The formula is largely a matter of personal preference, and practically any non-staining developer which will produce a good ordinary negative will act satisfactorily with films. It is the best policy, however, to use the formula recommended by the maker of the particular film selected, as this is sure to have been tested and found to give good results.

The majority of workers prefer, probably, a metol and hydroquinone developer. A typical formula is :—

Sodium Sulphite, 5 lb.
Sodium Carbonate, 2½ lb.
Potassium Metabisulphite, 1½ oz.
Metol, 160 gr.
Hydroquinone, 5 oz.
Potassium Bromide, ¾ oz.
Citric Acid, ¾ oz.
Water to 60 pints.

This solution should be used at a temperature of from 65° to 70° F.; it will keep about a fortnight, and may be worked repeatedly till signs of exhaustion begin to be evident.

Development.—The time of immersion should first be noted by developing a short trial strip cut from the film to be dealt with, taking care that the solution is not allowed to act long enough to clog up the high lights of the pictures, which, of course, are the darker portions of the negative. It is as well to rinse and fix the trial strip also, in order to see whether proper allowance has been made for the accompanying reduction in density. A suitable formula for the fixing bath is :—

Sodium Hyposulphite (" hypo "), 14 lb.
Potassium Metabisulphite, 1¾ lb.
Water to 56 pints.

Having developed the trial strip satisfactorily and noted the exact time, the wound length of film is placed in the dish or tank, moving the frame gently once or twice to dislodge air-bubbles and ensure even action.

It is then left for about a minute and again slightly agitated, after which it is allowed to remain undisturbed till the expiration of the ascertained time, when it is rinsed promptly in plain water and immersed in the fixing bath. There it should stay for a few minutes longer than is necessary to remove all creaminess and render the

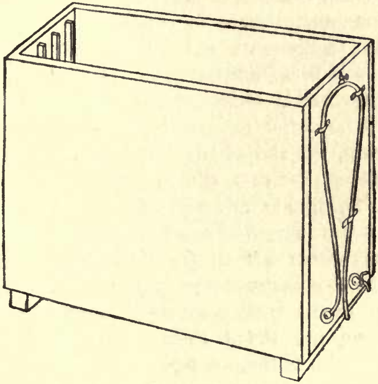


Fig. 21.—Siphon Washing Tank

pictures transparent. The film is then washed in running water for about one hour.

Drying the Film.—The film negative has now to be dried. This may be done, if desired, merely by mounting the flat frame holding the film on the standards used when winding, and revolving it quickly by hand or motor in a well-ventilated place free from dust. Many, however, prefer to transfer the film to a drying drum, and with a pin frame this transference is necessary.

The drying drum consists of two thick wooden discs, between which are nailed a number of thin springy laths, placed a short distance apart, as illustrated by Fig. 22. The drum has an axle through its centre, and is supported on a stand so that it may be revolved. The springiness of the laths is intended to compensate for the contraction of the film in drying.

A home-made drum is readily put together. One 1 ft. 3 in. in diameter will accommodate, say, 4 ft. of film to each turn, and allowing 1½ in. width to every convolution and a trifle over at the ends, a length of 40 in. will be ample for 100 ft. of film.

To wind, the end of the film is secured on the drum with drawing-pins or a clip and the drum is slowly revolved as the film is unwound from the developing frame, until all is transferred. The other end is then secured, and the film is either left to dry spontaneously in a warm room, with an occasional turn of the drum to prevent drops collecting, or the drum is revolved rapidly by a motor.

Cleaning the Dried Film.—When dry, the celluloid side of the film is cleaned from finger-marks or smudges with a soft rag slightly moistened with methylated spirit. The usual method of working is to have a small hole cut in the bench and covered with glass let in flush, the light from an electric bulb, or reflected daylight if preferred, being thrown upward through the opening. The bench should be covered with clean paper or fluffless cloth during the operation.

Remedying Under-Exposure.—Where subject, lighting and exposure have been under control the negative film should not require after-treatment, unless the worker's photographic technique is at fault. With subjects, such as topicals, hastily taken in the midst of obstacles or difficulties, however, defects are common. Perhaps the most frequent is under-exposure, which cannot always be helped. A film known beforehand to be under-exposed may sometimes be saved by prolonged development in a dilute solution. When, on the other hand, an under-exposed film has been developed in a solution of normal strength, it will, probably, have been

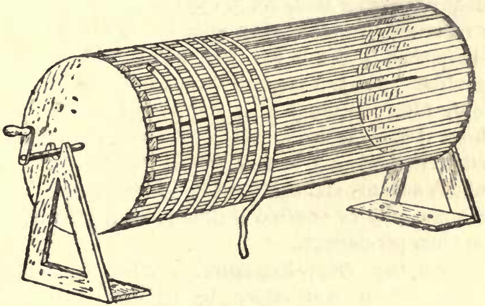


Fig. 22.—Drying Drum

either taken out too soon, in which case it will be thin, flat, and lacking in shadow detail, or else left in too long, when the result is excessive hardness and contrast. The remedy for the under-exposed and under-developed film is intensification; for under-exposure and over-development there is rarely an effective cure, though reduction in ammonium persulphate, which attacks the lights more than the shadows, may occasionally be worth while. This reducer may consist of 200 gr. of ammonium persulphate to each pint of water, made fresh as required. The film after the usual final washing is immersed in this till a little less reduced than is wanted, and is at once placed in a 5 per cent. solution of sodium sulphite, in which it is left for a few minutes, and then well washed.

A good intensifier, especially for topicals, is mercuric iodide. A suitable formula consists of 2 oz. of sodium sulphite and 45 gr. of mercuric iodide to each pint of water. The sulphite is dissolved first in about one-third of the water, warm ; the mercuric iodide being next introduced gradually, stirring well, till a colourless solution results. The remaining water is then added. This solution does not keep well, except in the dark, and should be prepared as required. The wet negative film, which need be washed for only fifteen minutes after fixing, is immersed in the bath till it gains density, and is then well washed for ten minutes, redeveloped in any strong developing solution for about as long, and again washed thoroughly. The redeveloping may be omitted if time presses, but the result is not then permanent.

Remedying Over-Exposure.—When the film is over-exposed, it will either be of excessive density, lacking in contrast and flat, or, if also under-developed, it will be thin and flat. For an over-dense flat film the remedy is treatment with Farmer's ferricyanide and "hypo" reducer ; while for the thin and flat type of over-exposure the best thing is first to reduce with ferricyanide and "hypo," which acts a little more on the shadows than on the lights, and then to intensify, so that sufficient density and contrast are obtained. The formula for the reducer is :—2 oz. of "hypo" to the pint of water, to which is added, directly before use, from 1 oz. to 2 oz. per pint of a 10 per cent. solution of potassium ferricyanide. The "hypo" is first dissolved in about a third of the water warmed, the remaining water being then added and the ferricyanide solution stirred in. The bath should be used at once, as it does not keep well. It is stronger or weaker according to the proportion of ferricyanide.

An over-exposed film commonly shows all possible detail, whereas in under-exposure the shadow detail is more or less lacking. It does not always follow that a thin film has been wrongly exposed; it may have been correctly exposed and insufficiently developed. In that case, a slight intensification will rectify matters.

CHAPTER VI

Printing the Positive Film

Printers.—To make a positive film from the negative a machine called a printer is employed. Printers are of two kinds, the older continuous type, in which the two films are run together in contact past an exposure opening without stoppage, and the more modern "step-by-step" pattern, in which the films are stopped intermittently by a claw movement resembling that in the camera during exposure. The step-by-step printer gives the more accurate registration and is that generally adopted by professional workers, the machines being usually electrically driven. They are, however, elaborate and expensive. The continuous pattern is cheaper, and is well suited for work on a small scale.

A typical hand-driven continuous printer is shown by Fig. 23. The negative film is contained on the spool A and the unexposed positive film on the spool B, the two being passed, emulsion sides together, through a pressure gate C in front of the exposure opening. At D is a sprocket-wheel under which the films are threaded, a spring roller preventing slipping, while at E is the driving handle and a pulley-wheel for connecting to a motor if desired. The electric lamp F supplies the necessary light, and may be shifted nearer to, or farther away from, the opening, to suit negatives of different density, by the lever G. If preferred, incandescent gas can be fitted. In use, the panel H is mounted on a partition or in front of a light-tight box, so that no light reaches the film except through the exposure aperture. The films, as run through, are received in a basket or other receptacle. Higher-priced printers have two additional spools on which the negative and positive films are wound off.

Using the Camera as a Printer.—It is quite possible to use the camera itself for printing. Some cameras have slots for the purpose, but with the majority it is necessary to cut a narrow slot at the top and bottom, in line with the gate, as shown at A and B in Fig. 24. These, of course, must be provided with sliding covers to keep out light when the camera is in normal employment. An arm C with a spindle to take a spool D, holding the negative film, is attached at the top. The lens should be removed and the shutter fully opened. The camera is stood on a bench against a partition E in which a small opening is cut, and an electric bulb F or an incandescent gas burner is adjusted a short distance behind. If preferred, the light may be enclosed in a box. A blackened card-

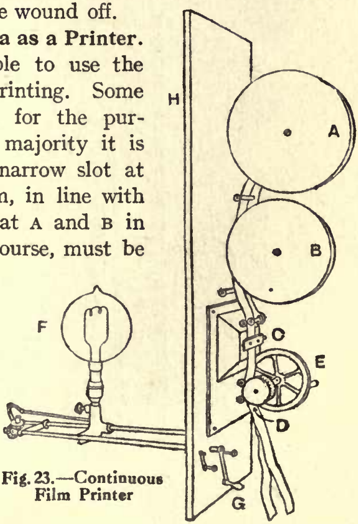


Fig. 23.—Continuous Film Printer

board tube G should be supported between the partition opening and that in the camera. The roll of unexposed positive film is loaded into the upper film-box H, which is then inserted in the camera. The negative film is threaded through the top slot, through the gate,

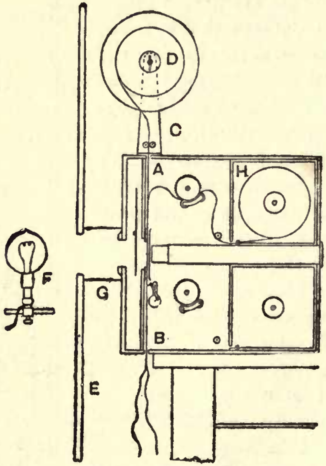
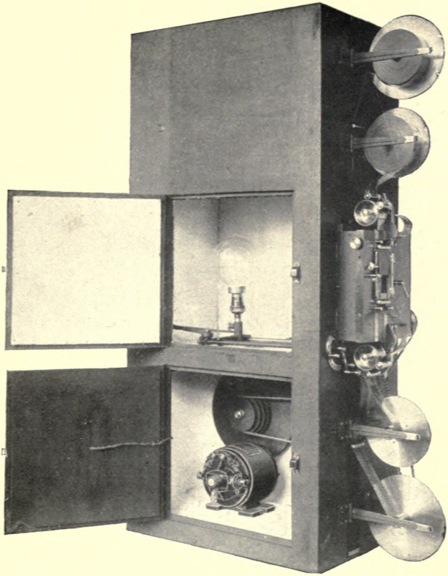


Fig. 24.—Printing Positive Film with the Camera

noting that the picture is centrally masked, and out at the bottom; while the positive film is threaded under the guide roller, under the upper sprocket, through the gate in contact with the negative film, and out at the lower slot. It must be seen that the two gelatine surfaces come together, and that the pin escapement engages properly in both films at once. Having closed the camera,



FILM PRINTER OPERATED BY ELECTRIC MOTOR

(*Motor, British Thomson-Houston, $\frac{1}{10}$th h.p.; Printer, Williamson type*)

printing is done by turning the handle at a regular and rather slow rate. The precise speed depends on the light and the density of the negative, and should be found by exposing and developing a short trial piece of film. For printing by this method it is usually necessary that the negative films should have been taken by the same camera, otherwise the mask may not be central with relation to the pictures.

Developing Positive Film.—Having finished the printing, the positive film is collected on a spool, in order to handle it conveniently, and is then wound on a frame for developing, which is done in just the same way as with negatives. The same developer may be used if care is taken not to clog up the high lights, but most workers prefer a solution kept specially for the purpose. A good formula is :—

Sodium sulphite	3½ lb.
Sodium carbonate	3 ,,
Potassium metabisulphite	1 oz.
Hydroquinone	8½ ,,
Potassium bromide..	1 ,,
Water	to 60 pints.

Instead of developing for a previously ascertained time, as with negatives, it is better to examine progress by removing the frame from the dish or tank and holding it in front of the dark-room lamp. If correctly developed, when viewed from the surface the picture should seem a shade too dark, the unexposed margins, however, remaining white. Tilting the frame a little and looking through the outer strand of film, full detail ought to be visible in all parts and the shadows should be a trifle dense.

When development is considered complete, the film is rinsed and fixed as in the case of a negative, using the same bath. It is then washed, dried, and cleaned, as before described. Positive films may be, and sometimes are, intensified or reduced, but all such after-treatment is best confined to the negative. Assuming a black-and-white result is desired, the positive film is now ready for projection. A trial on the screen often shows the expediency of "cutting out" parts here and there. When this is done, the film has to be joined again at the cut portions with film cement.

Toning Positive Film.—It may, however, be wished to have the positive of a special tone to suit a particular effect. This may be attained by treating it in a chemical toning bath. Practically any of the formulæ used by the photographer for toning bromide prints is suitable, but a few approved ones are here given. Strict cleanliness is necessary in the tanks or dishes employed, and it is certainly desirable to keep separate receptacles for each different toning bath.

For warm sepia and brown tones the sulphide bath is excellent. Two solutions are required:—(*a*) In each pint of water dissolve ¼ oz. of ammonium bromide and ¾ oz. of potassium ferricyanide; (*b*) in each pint of water dissolve 290 gr.—practically two-thirds of an ounce—of pure sodium sulphide. The film is first immersed in the ferricyanide solution (*a*) until bleached to a yellowish white, and is then washed for one minute and transferred to the sulphide solution (*b*), in which it assumes its final colour. The film is lastly washed for half an hour. The sulphide solution had better be worked outdoors, as the smell is disgusting; the fumes, also, might be deleterious to sensitive materials, such as unexposed or undeveloped films. With a fresh sulphide bath density is slightly increased. The ferricyanide solution may be used over again, but the sulphide solution does not keep and should be thrown away. As stale or common sulphide will not tone well, and may even have a reducing action, this chemical should be purchased from a reliable source.

For warm purple-black and reddish tones the copper ferricyanide bath may be employed. This intensifies as well as tones, and is, therefore, useful for improving thin positives. A good formula is :—In each pint of water dissolve 30 grs. of copper sulphate, ¾ oz. of neutral potassium citrate, and 25 grs. of potassium ferricyanide. Well wash after toning.

Blue tones are very effective for moonlight scenes, seascapes, and some other purposes. These may be obtained with an iron bath, a suitable formula being :—In each pint of solution dissolve ¼ oz. of ferric ammonium citrate, ¼ oz. of potassium ferricyanide, and 4 oz. of acetic acid. After toning in this bath the high lights of the pictures will be slightly stained and clogged ; the film should be washed till this effect disappears. The image is intensified to some extent, so that the positive should be on the thin side.

In making up the foregoing baths each chemical should be dissolved separately in a portion of the water, and then mixed in the order given, adding water to obtain the necessary total. There are various other toning baths, for information on which photographic works may be consulted. With practically all solutions used for toning, great care is requisite not to render the film too opaque for projection, as the extent to which a toned image will block the light is greater than might be supposed by merely looking through it.

Tinting Positive Films.—Another method of varying the colour of a positive film, less troublesome than toning, but not quite so effective, is known as tinting, and consists of immersing the film in a weak aniline dye solution. The effect is to stain the whole film, both lights and shadows, though the real underlying colour of the image is not actually altered. In toning, on the other hand, the black silver deposit of the image is changed by the bath to a red, brown, or blue, as the case may be, while the lights of the picture remain practically white. Tinting does not suit all subjects, but with the majority very good effects may be secured. For titles and announcements it is often indispensable.

The aniline dyes should be water-soluble, and are usually obtained in the form of a dry powder. A sufficient quantity of dye solution must be made up to fill the dish or tank. The exact strength varies with different colours and to some extent with the subject, and it is advisable to make a few trials with short strips of waste film till the effect is considered right. The bath should be of such a strength that, say, seven minutes' immersion of the film will give a tint a trifle deeper than is wanted. The correct amount of dilution having been adjusted, the film is immersed for the time stated, and is then washed for about a minute to remove excess of dye and prevent streakiness. This slightly reduces the tint, which must be allowed for. For firelight effects, eosine red is excellent, and even ordinary red ink is often useful. For moonlight scenes, methylene blue may be used; for daylight, a faint pink; for sunshine, a golden yellow, such as naphthol. Almost any colour may be employed for titles and announcements, though some artistic discretion is called for. During the dyeing operations waterproof gloves are advisable for the hands.

Long films have to be wound on wooden frames and immersed in large tanks of dye solution for about five minutes, followed by about half a minute in clean water, to remove excess dye and prevent streakiness. With comparatively short lengths of film, however, up to about 30 ft., the tinting may be done by simply drawing the film to and fro through a flat dish containing the dye solution. A deep whole-plate (8½ in. by 6½ in.) porcelain developing dish is very suitable. The film is supported by the two hands, so that a loop dips in the dye, gelatine side upwards, and it is shifted to and fro by rapid yet gentle movements of the fingers, each portion in turn being thus immersed and gradually saturated. The parts not in the dish will curl up outside on the bench, which should be clean and preferably covered with oilcloth. As before, a slight rinsing should be given.

TITLES

In the early days of cinematography, titles and explanatory letterpress were shown by means of stationary lantern slides, but the modern practice is to have them printed on the film itself, in the proper places. Since the film must not be stopped, the titles need to be repeated through a length of several feet.

For the average title, consisting of transparent wording on a black ground, white enamel letters are mostly used, but a good effect can be obtained by cutting them carefully in white cardboard. The letters are laid on a dead black horizontal surface, such as velvet spread taut on the floor or over a low bench. The camera has then to be pointed downward, so that the lens axis is perpendicular, to accomplish which a special stand or a tilting-board is needed. A suitable contrivance is shown by Fig. 25. The camera A rests on the shelf B and is screwed to the bracket C, its lens pointing down through a small opening. The shelf B is fixed by struts to a sliding board D, which may be adjusted at any convenient height on the upright stand by a winged nut, working in a slot in the board E. A title is seen arranged on the low table F, ready for photographing. The work should be done in a well-lighted room or outdoors, unless arc-lamps are available. Two of the latter would be required, one at either side of the copy.

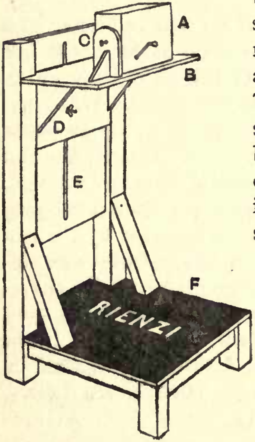


Fig. 25.—Stand and Table for Photographing Titles

The exposure varies with the light, and had better be tested with a meter. It should be ample but not excessive, or there will be a lack of vigour in the negative, and the positive, in consequence, will not be so effective. Some workers prefer to use the slower positive film for making the negative, thus getting more contrasty results. From 5 to 12 ft. is sufficient length for a short title or an incident heading, while for more lengthy notices the operator should note exactly how long it takes him to read them through at a normal rate, and allow double that time for the public benefit, estimated at one foot for each second.

From the negative film of the title a positive is next made in the usual manner, taking care to get transparent lettering and an opaque ground. This is a matter of correct exposure and the use of a developer tending to give a dense black image without staining. Glycin is very suitable for the purpose, a good formula being :—

Glycin	1¼ lb.
Sodium sulphite	3¼ „
Potassium carbonate..	6 „
Water	to 60 pints.

If this proves too strong for the particular brand of film, add more water. Any veiling of the letters through over-exposure or over-development will obviously detract from legibility, besides having an unsatisfactory effect. If only slight, such veiling may be removed with the ferricyanide and "hypo" reducer.

The foregoing remarks refer to plain titles. Those with ornamental borders or fancy lettering are usually drawn or painted by artists on white cards and then photographed as before described. In that case, the copy may if desired be pinned on a wall or vertical easel and the camera worked in its ordinary horizontal position. By cutting an opening in the centre, any fancy border can be used as a frame, and employed with different titles.

If only a single copy of the title or inscription is wanted, it saves time and expense to have the original set up, drawn, or printed in black letters on a white ground and to thread the film celluloid side to the gate when photographing. The negative will then show white letters on a black ground, and may itself be used for projection without having to make a positive. The stouter positive film should preferably be employed for the exposure, however, and it is necessary to develop for a specially contrasty black-and-white result.

There is yet another way of dispensing with the making of two films when titling. This is to copy the lettering on a dry-plate, say lantern size ($3\frac{1}{4}$ in $\times$ $3\frac{1}{4}$ in.), by means of an ordinary quarter-plate camera. The negative obtained is then inserted in the carrier A (Fig. 26) of an enlarging lantern having sufficient bellows extension to permit its employment for reducing. The printer, or else a cinematograph camera B furnished with two slots and having an arm C to hold the spool of positive film, is stood in line with the enlarging lantern, the distance and focus of the latter being adjusted until a sharp reduced image of the title is projected upon the film in the gate. The exposure is then made by slowly turning the camera handle, the result when developed being a positive film of the lettering. The lantern needs to be boxed-in, as shown, the camera lens being removed and a short tube D of blackened cardboard placed between the lens opening and that in the box. If preferred, the positive film may be inserted in the upper film-box of the camera, threading it under the top sprocket, through the gate, and out at the lower slot. For professional workers, special printers on the above principle, having an enclosed lamp, condenser, and extension bellows, are obtainable. Here there is no particular saving of time, but economy is effected by the difference in cost between a single lantern plate and a length of negative film, and, when well done, lettering reduced from a larger negative will probably be rather better technically than that made by contact from a film the same size.

Title films are usually tinted, while incident headings

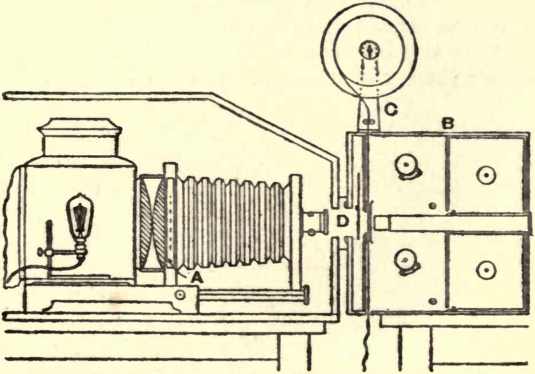


Fig. 26.—Making Title Films by Reduction

are often left plain, but there is no rigid rule. The reason why lettering is almost always white on a black ground, instead of black on white, is from regard to the eyes of the spectators, which would otherwise be unnecessarily dazzled by the blaze of light on the screen. The pictures, also, would seem darker and less effective by contrast. The titles and headings are joined up to the picture film at the right places, cutting the latter wherever necessary to allow of the interpolation.

CHAPTER VII

The Projector Described

The cinematograph projector consists of an optical lantern in combination with a mechanism for giving intermittent movement to a film bearing a series of positive photographic images. The film receives sixteen

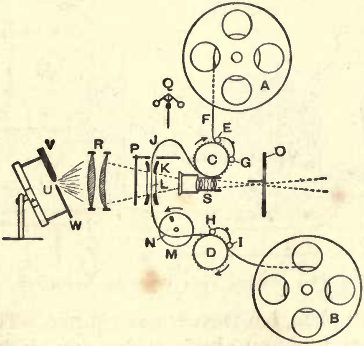


Fig. 27.—Essential Mechanism of the Projector

impulses every second, and for the same number of times in that period is brought to a standstill in the path of the beam of light issuing from the lantern through the gate of the machine. During the times that the film is moving, a rotary shutter cuts off the light from the screen.

The mechanism essential to the cinematographic effect is illustrated by Fig. 27. Two spools carry the film F, the top one A being the feed spool and the bottom one B the take-up spool. An upper and lower sprocket-wheel C and D, working in unison, engage with the film perforations. The film passes from spool A, between sprocket C and spring pressure rollers E G, forms a loop at J, passes through gate K, past the exposure aperture L, goes under the dog-wheel M, the pin of which in striking the film gives the intermittent movement, between sprocket - wheel D and pressure spring rollers H I, and finally to the take-up spool B. The top spool A rotates by reason of the pull made on the film and is free to revolve. The lower spool B is turned continuously by chain or belt, so that the film is tightly wound thereon as it comes from the sprocket D; there is a means of compensating for the increasing size of the roll of film on B. The gate K has springs and pressure pads which hold the film steady after its downward motion; and the channel through which it travels is recessed, contact only obtaining at the edges where the perforations are. The gate turns on hinges after the manner of a door (see Fig. 28), to assist insertion and threading of the film, being fastened by a

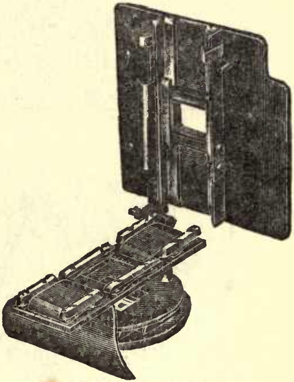


Fig. 28.—Gate Mechanism

catch and held by a spring. The shutter O is a revolving disc with open sector, and is geared in such a manner that the open portion arrives opposite the exposure aperture and optical system just at that moment when the film is brought to rest. A safety drop shutter P is situated between the gate and condenser R, its rise and

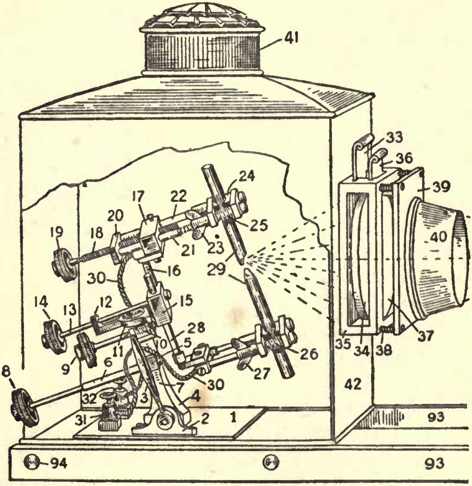


Fig. 29.—Lantern or Lamp-house cut away to show Arc-lamp

fall being controlled by the governor Q. The governor does not allow of the shutter rising till the mechanism is running at the rate of showing sixteen pictures per second, at which speed it is safe to allow the powerful light to pass through the celluloid film. The objective

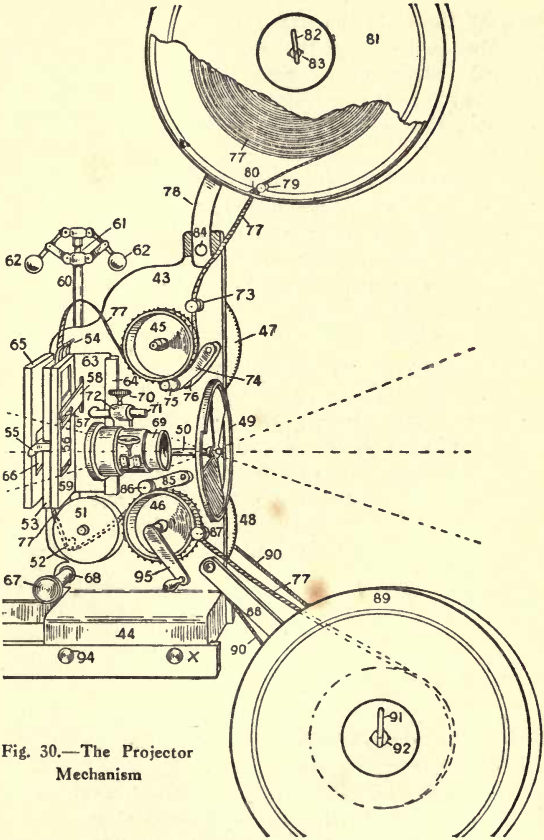


Fig. 30.—The Projector Mechanism

lens for throwing the image upon the screen is at S, between the gate and the rotary shutter. The lantern situated immediately behind the condensing lenses R contains the necessary source of illumination, an electric arc-lamp, the carbon pencils V W of which create the arc at U.

A diagram of an up-to-date projector, in which every part is given a reference number, is presented by Figs. 29 and 30. This projector combines the good points of most of the best machines on the market, avoiding both mere cheapness and expensive elaboration; and it is thought that the diagram and key herewith have considerable practical value in familiarising the operator with the names of the parts of the machine.

Arc-lamp: 1, base; 2, clamp to fix lamp to lantern base; 3, clamp handle; 4, main upright of lamp; 5, block fitted with pinion; 6, pinion rod; 7, rack in which the pinion works; 8, milled head; 9, milled head to rod fitted with worm screw at 10; 10, worm screw to engage with horizontal spur-wheel turning under 11, to give a circular movement to arc; 11, revolving head of main standard 4; 12, support for rod 13; 13, rod fitted with pinion inside block 15; 14, milled head, which on being turned causes the pinion in 15 to engage with teeth of rack 16, and with teeth on opposite side of rod 28, thus causing the upper and lower carbons to be drawn together or separated as required; 15, pinion and rack holder; 16, rack of upper carbon holder; 17, block in which screw 18 works, pushing top carbon holder forwards or backwards; 18, screw turning loosely in block 20 and threading through 17; 19, milled head of top carbon holder; 20, block to which 21 and 22 are fixed; 21 and

22, parallel rods supporting jaws 24; 23, wing nut securing jaws; 24, jaws; 25 and 26, springs to push jaws apart on loosening nuts 23 and 27; 27, wing nut securing jaws; 28, vertical rod holding lower carbon holders; 29, carbons; 30, flexible insulated wires leading to terminals; 31 and 32, terminals.

Optical system and lantern parts: 33, slider carrying back lens of condenser; 34, back condenser lens; 35, condenser staging; 36, slider carrying front lens of condenser; 37, front condensing lens; 38, spring; 39, front of stage, behind which ordinary slide carrier is placed; 40, shade cone or funnel; 41, cowl; 42, front of lantern body.

Cinematograph mechanism: 43, main upright support; 44, base; 45, top sprocket; 46, bottom sprocket; 47, upper spur-wheel of driving mechanism; 48, lower spur-wheel; 49, shutter with extra or "non-flick" blade; 50, spindle; 51, dog-wheel; 52, pin; 53, hinged film gate; 54, skate spring holding film steady during its passage; 55, catch of film gate; 56, opaque slide of safety shutter, drawing up by pin 57, working in 58, raised when opposite end is pressed by governor rod 61; 59, framework of safety shutter; 60, governor rod tube; 61, governor rod; 62, ball weights; 63, slider working in 64, carrying with it objective lens 69, film gate shutter and heat shield 65; 64, guide for slider 63; 65, heat shield with aperture at 66; 67, milled thumbscrew operating the rod 68 which carries (on opposite side of upright 43) a pinion which communicates with a rack-work which gives the vertical motion to object lens, film gate and heat shield, all moving together; 69, objective lens moved by rack and pinion, operated by the milled head shown; 70, thumbscrew holding lens carrier 72 in any position along the rod 71; 71, rod support for lens carrier; 72, carrier for lens; 73, film guide roller of top sprocket; 74, arm furnished with handle at 75, sprocket pressure roller at 76; 77, film; 78, arm support for top spool; 79, guide roller for film; 80, slit in spool case; 81, removable cover of casing to spool; 82, pivoted pin locking cover of spool to support; 83, supporting spindle on which spool rotates; 84, bolt securing arm 78; 85, spring arm carrying sprocket pressure reel, and handle 86; 87, guide reel; 88, supporting arm for lower spool case 89; 90, belt or chain drive; 91, pivoted pin to lock spool case to support 92; 92, supporting spindle on which lower spool rotates; 93, base both of lantern and cinematograph; 94, bolt heads; 95, operating handle.

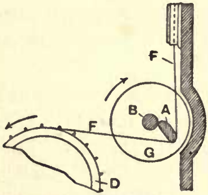
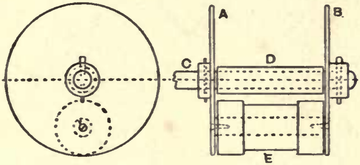


Fig. 31.—Original Type of Dog Movement

THE INTERMITTENT MOVEMENT

In the projecting mechanisms so far illustrated, only the dog movement has been shown, but there are other means of obtaining the intermittent movement required, the most common being that known as the Maltese cross. These two movements will now be explained in detail.

The Dog Movement.—This movement requires a top and bottom sprocket-wheel and the dog-wheel (see Fig. 27). The original dog movement, invented by Demeny, is shown by Fig. 31. A disc G revolves on the centre B, and has an adjustable pin A, which, on each revolution of the disc, strikes the slack film F, drawing it down through the gate for the distance of one picture-space. Some of the slack film is taken up by the continuously rotating sprocket-wheel D. Fig. 31 is merely diagrammatic, but details of an actual dog are given in Figs. 32 and 33. Two metal discs or cheeks A and B, $2\frac{1}{8}$ in. in diameter and $1\frac{9}{16}$ in. apart are mounted on a $\frac{1}{4}$-in. diameter spindle C; linch-pins fasten the bosses of the discs to the spindle. D is a vulcanite roller, $\frac{3}{8}$ in. in diameter, revolving freely on the spindle, and its object is to save wear and tear of the film, which during part of the revolution of this



Figs. 32 and 33.—Details of Dog Movement

mechanism would otherwise be in contact with the metal spindle. The dog itself, or striker, is the eccentrically mounted vulcanite roller E, $\frac{3}{4}$ in. diameter, which runs on a $\frac{1}{4}$-in. spindle placed $\frac{11}{16}$ in. from the central spindle, centre to centre. The dog hits the slack film once during every revolution of the central spindle, which has a speed of 16 revolutions per second. The central clearance on the dog-roller is to lessen the wear on the film. The dimensions given are, in general, suitable for adoption with 32-teeth sprocket-wheels, but it will be understood that the diameter of the dog-roller and its distance from the central spindle ought to be designed to suit the gearing and arrangement of the individual machine.

The Maltese Cross or Geneva Movement.—This requires three sprockets in addition to a disc- or pin-wheel. Besides the top and bottom sprockets, there is one (see Fig. 34) below the gate, and so placed as to engage with the film perforations. Fixed to its side is a Maltese cross D. A disc B, carrying on its side a second disc A, and a pin at G, is made to rotate continuously in the direction of the arrow. During its motion the pin G

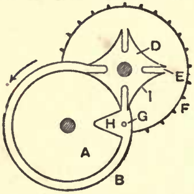


Fig. 34. — Four - armed Maltese Cross Movement for Four-picture Sprocket-wheel

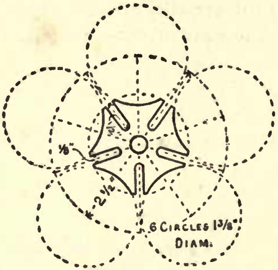
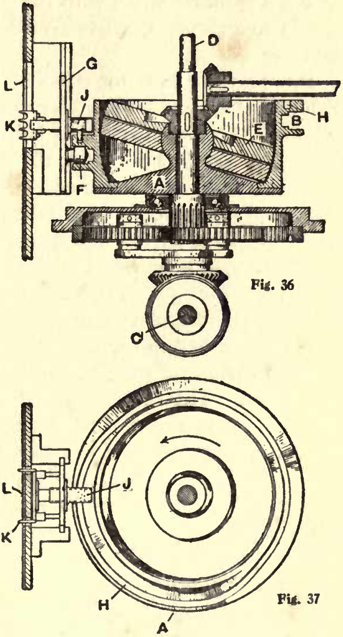


Fig. 35.—Five-armed Maltese Cross for Five-picture Sprocket-wheel

enters the slot E, and at a certain point begins to turn the Maltese cross; the points of the cross pass into the notch H of disc A and thus allow the sprocket-wheel to make a one-quarter revolution; then it is brought to a standstill and held locked by the concave edge I coming opposite to, and in contact with, the convex plain edge of disc A. When disc A has made a complete revolution, the same action takes place, and so on, on each corner of the cross. The advantages of this movement over the dog action are greater steadiness with less jerking and strain on the film, but against this must be placed more friction and wear in the mechanism. In a recent patent, this is overcome by enclosing both the pin-wheel and the cross in an oil bath.

Four-picture sprocket-wheels are generally used, each having sixteen pairs of projections. The gearing may be as follows:—Three 4-in. diameter toothed wheels geared together, one on the top sprocket-wheel spindle, and another on that of the bottom or reeling-off sprocket-wheel, the intermediate 4-in. wheel having attached to it a $1\frac{1}{2}$-in. wheel which gears with a 3-in. wheel connected to the driving handle. To the end of the pin-wheel spindle are fixed, firstly, a 1-in. wheel gearing with the bottom 4-in. wheel; and, secondly, a heavy balance wheel. The pin-wheel thus makes four revolutions to each revolution of the sprocket-wheels, and at the



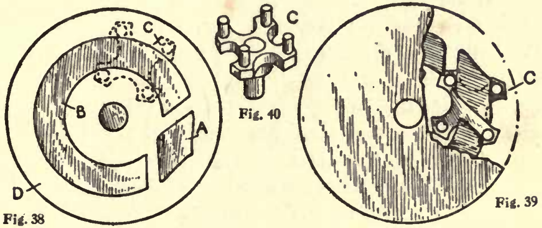
Figs. 36 and 37.—Details of Kineto Cam and Claw Movement same time one turn of the handle is equivalent to eight pictures.

For a sprocket-wheel with twenty projections, equivalent to five pictures, a five-armed cross is necessary, as shown in Fig. 35.

Pin or Claw Movement.—This is practically identical with that described on p. 16 for use in the cinematograph camera. It is not regarded as being so durable as either the dog or the Maltese cross, though exceedingly steady.

Cam and Claw Movement.—A claw movement of a particularly interesting kind is employed in the Kineto machine. It is worked by means of a double-cam, and the mechanism is shown in plan by Fig. 37 and in vertical section by Fig. 36. The cam A has a groove B in its outer periphery and a smaller one H in its top face; it is driven through "sun and planet" gearing by a handle fitted to horizontal shaft C, which makes two revolutions per second. The cam is carried by a vertical shaft D, and inside it is a pair of balancing discs E, which steady the drive. Groove B in the cam engages with roller F, and in so doing imparts vertical movement to the feed slide G, which movement is equal to the height of a picture, ¾ in. The second groove H, in the top face of the cam, engages with the part J, and gives the feeding claw K a to-and-fro movement. Thus, as the feed slide travels downwards, the claw moves forward and engages with the perforations in the film L; on the return movement the claw is withdrawn free of the film. The gearing is such that the film is moved eight times during one revolution of the handle. Of the one-sixteenth of a second between the coming to rest of two successive pictures, only one-fifth of the time is occupied in moving the film.

The Diamond Cam Movement.—In Power's "cameragraph" projector, the intermittent movement is obtained by means of the cam A, locking-ring B, and cross C (Figs. 38 to 40), all these being of hardened tool steel. Ring and cam are in one solid piece with the disc D, which is rigidly secured to the main spindle or shaft of the machine, while the cross C, with which they engage, is secured to the end of the spindle of the intermittently-moving sprocket which works the film. The cross has four arms with a



Figs. 38 to 40.—Details of Power's Diamond Cam Movement

stout pin on each, the whole cut from a single piece of steel. As the disc D rotates, the cross C is held locked while the ring is sliding between the pins (see Fig. 38), but when the cam A is reached, the pins slip between it and the ring, thus causing the spindle to which the cross is attached to make a quarter-turn. The mechanism is enclosed in an oil-tight casing, and is kept liberally supplied with oil, which ensures silent and easy running.

Friction Grip Movement.—An arrangement tried some years ago consisted of two cam-shaped rollers or wheels revolving in opposite directions and mounted in such a way that during part of their revolution they gripped the film which passed between them, and drew it down one picture-space.

The Shutter.—This is a one-blade, two-blade or three-blade plate which revolves between the film and the projecting lens or immediately in front of that lens, its speed being one revolution per picture, that is, 16 revolutions per second. It may be of the simple form shown at A (Fig. 41), in which the blade or sector interrupts the light rays once every revolution during the period when the film is moving; or it may have one or even two extra "non-flick" sectors (see D, E, F and G), which interrupt the light *while the film is still.* An extra blade or sector robs the screen of some of the light, but it softens the harshness of the sudden alternations of brilliant light and pitch darkness and eliminates much of the flicker. In many machines the extra or "non-flick" blade is made of celluloid or gelatine, stained to a violet colour; but the tendency nowadays is to make the "non-flick" blade opaque. The effect of the second blade is sometimes obtained by doubling the width of the single blade (see B) and running the shutter at twice the usual speed; thus, on its first passage across the lens it darkens the screen for the movement of the film, and on its second passage it acts as a "non-flick" blade; it will be seen that the same amount of time is allowed for each film movement as when the ordinary shutter rotates at one-revolution-per-picture speed.

There may be a separate shutter to give the "non-flick" effect, but it is not easy to see the advantage of introducing still another moving part, when the addition of a blade to the single shutter does all that is necessary.

Some makers offer a choice of shutters—a three-blade

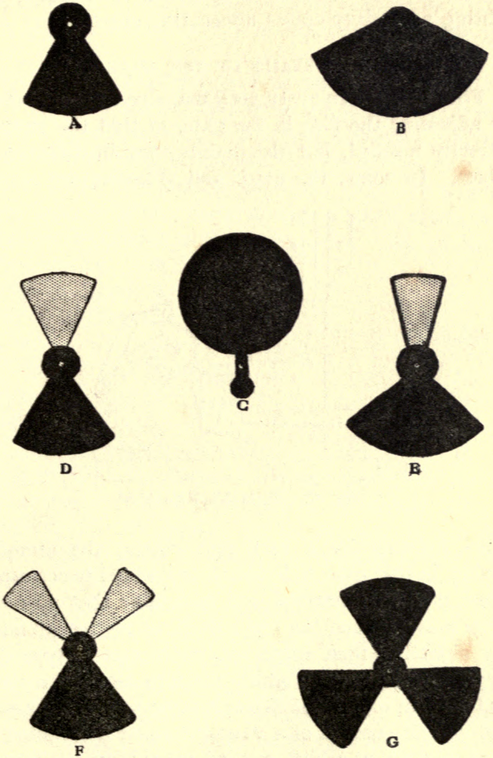


Fig. 41.—Various Types of Shutter shown diagrammatically

one for direct-current lighting and a two-blade one for lighting with sixty-cycles alternating current.

OTHER DETAILS OF THE MACHINE

Film Mask.—In every good machine there is provision for adjusting the film in the gate, so that the picture is correctly masked, but the details vary in different machines. In some, the mask and objective are made to

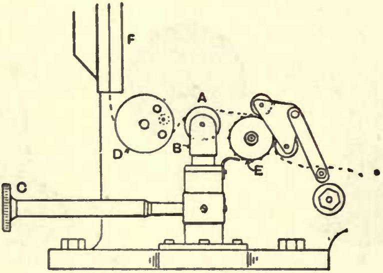


Fig. 42.—Wrench's Film Mask

move together by a rack and pinion, the illuminant having, in that case, to be raised or lowered to correspond. Those methods, however, are preferable that do not involve movement of the mask itself, as neither illuminant nor objective then needs readjustment. A typical example of a device by which the film alone is moved is that used in one of the Wrench projectors, and shown in Fig. 42. It consists of a vulcanite roller A mounted in a brass casting B, which can be moved up or down by a milled-head screw C actuating a rack and pinion. The roller is placed between the "dog" D and the bottom sprocket wheel E, and thus enables the film to be moved to any desired extent until it is correctly masked in the gate F.

Take-up Mechanism.—This mechanism prevents strain on the film as the diameter of the wound-off portion increases. Sometimes, as in the early machines, a spring driving band is used, which will yield whenever the film gets taut; but the modern tendency is to use a more positive form of drive and to provide a spiral spring and washers on the spindle of the lower spool. Fig. 43 shows a typical device. The winding-off spool A slips over the spindle B, and is kept in place by a drop-catch C. The driving pulley D is soldered to a tube E that fits loosely over the spindle, and has fixed to it at the other end a metal washer F. Another washer G, furnished with a nut, screws on the spindle, as shown, and is secured by a set-screw, while between the washer G and the pulley is a spiral spring H. As the driving band or chain causes the pulley to revolve, the pressure of the washer F against the spool sets that also in motion; but when the diameter of the wound-off film increases, the spool is obviously able to slip and to reduce its speed. The tension of the spring has to be adjusted to a nicety by means of the screw-washer G, so that just sufficient pressure is applied to the spool to keep it steadily in motion, yet not enough to move it forcibly against the tautening of the film.

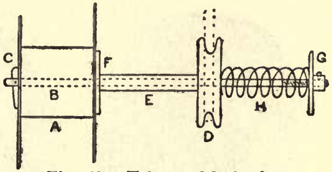
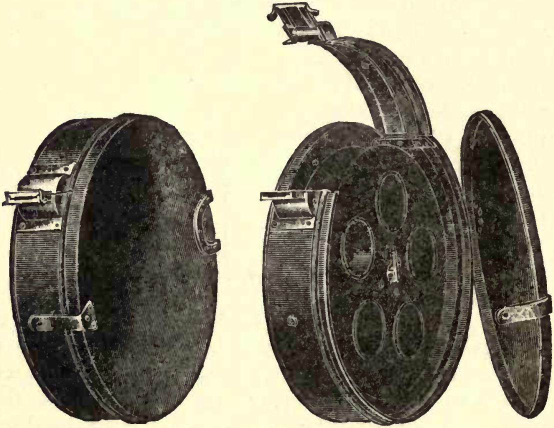


Fig. 43.—Take-up Mechanism

Safety Spool Cases.—Among the refinements designed to make a serious flare-up impossible, there must be mentioned safety spool cases, of which there is a number of patterns on the market. The pattern shown by Figs. 44 and 45 is typical of them. The film passes through a restricted opening and under a roller so



Figs. 44 and 45.—Safety Spool Case or Film Box

adjusted that while they add but little to the resistance there is no room for air to pass into the case with the film. Should a projecting piece of film be ignited, the fire dies when it reaches the entrance to the case.

Safety Cut-off Shutter.—The Cinematograph Act, 1909, states that " lanterns shall be provided with a metal shutter which can be readily inserted between the source of light and the film-gate." (See also p. 173.)

CHAPTER VIII

Optical System of the Projector

How a Lens Acts.—There are six kinds of lenses used in various combinations for projection purposes, and these are shown in Figs. 46 to 51. Fig. 46 shows the bi-convex, convexo-convex, double-convex, or equi-convex ; Fig. 47, the plano-convex ; Fig. 48, the concavo-

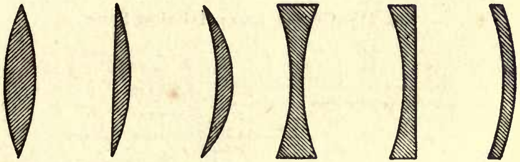


Fig. 46 Fig. 47 Fig. 48 Fig. 49 Fig. 50 Fig. 51

Fig. 46.—Bi-convex Lens. Fig. 47.—Plano-convex Lens. Fig. 48.—Concavo-convex Meniscus. Fig. 49.—Bi-concave Lens. Fig. 50.—Plano-concave Lens. Fig. 51.—Convexo-concave Meniscus

convex meniscus ; Fig. 49, the bi-concave, concavo-concave, double-concave, or equi-concave ; Fig. 50, the plano-concave ; and Fig. 51, the convexo-concave meniscus. The first three are thicker at the centre than at the edge, and are called convex lenses. The second three are thinner at the centre than at the edge, and are called concave lenses. In any convex lens the inclination of the two faces towards one another increases from the centre or axis towards the edge. Its section may be regarded as being built up of a number of prisms of gradually increasing angle, arranged with their bases inwards or towards the centre. The general effect of a convex lens is to render transmitted rays of light more convergent—that is, to bend them towards the centre or axis, as indicated in Fig. 52.

In any concave lens the inclination of the two faces

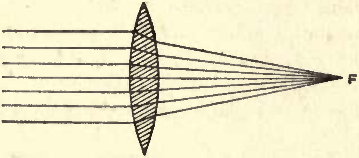


Fig. 52.—Convex Lens: Principal Focus

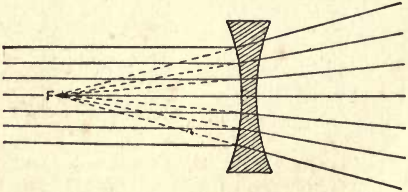


Fig. 53.—Concave Lens: Principal Focus

towards one another increases from the edge towards the centre or axis, and is the exact opposite to a convex lens. Its section may be regarded as being built up of a number of prisms of gradually increasing angle, arranged with their bases outwards, or away from the centre. The general effect of a concave lens is to render transmitted rays of light more divergent—that is, to bend them away from the centre or axis, as in Fig. 53. In Figs. 52 and 53 F indicates focus.

The Condenser.—The condenser has nothing to do with the formation of the image on the screen. Its function is solely to condense, collect, or concentrate the divergent rays of light emitted by the jet or lamp into a parallel or very slightly convergent beam, and thus illuminate the lantern slide or the cinematograph film as equally and intensely as possible. A single condensing lens would not do this properly, owing to the spherical aberration found in all single lenses. Hence a combination of two or more lenses is required, the one acting practically as a corrective to the other.

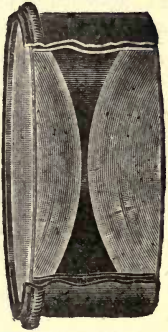


Fig. 54.—Ordinary Form of Condenser

The ordinary condenser is composed of two plano-convex lenses mounted in a metal case, with the convex surfaces nearly touching (see Figs. 54 and 55). It is suitable for use with the shorter focus projection lenses. With the longer focus projection lenses, special condensers, as in Figs. 56, 57, and 58, give better results, because of their transmitting more light and giving more even illumination than the ordinary form. Fig. 56 shows a concavo-convex meniscus and a plano-convex; Fig. 57, a concavo-convex meniscus and a bi-convex; and Fig. 58, a combination of a concavo-convex meniscus with two plano-convex lenses. In each of the three latter the meniscus is placed nearest the light.

Generally speaking, the best form of condenser from the optical standpoint is that which, from its short focus, permits the transmission of a wide angle of light, and distributes it evenly over the entire field of the disc of light, which illuminates the slide, the film, and the screen.

When a bi-unial lantern is used for slides, with dissolving view effects, it should be fitted with a pair of 4½-in. condensers. These will adequately cover the English standard slide, having either a cushion or a dome-shaped mask from corner to corner. But when the cinematograph lantern is also used for slides, which are often not of a very high quality, a 4-in. condenser will usually suffice. A condenser which is larger than is

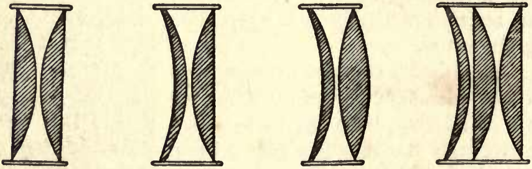


Fig. 55 Fig. 56 Fig. 57 Fig. 58

Figs. 55 to 58.—Diagrams of Ordinary and Special Forms of Condenser

absolutely necessary wastes the light, while one that is too small does not sufficiently illuminate the picture.

When purchasing a condenser, see that the lens that is to be placed next to the slides is entirely free from defects, such as air bubbles and striæ, as these might show rather unpleasantly on the screen. Both lenses in a condenser should be mounted loosely in the metal case or cell, in order to allow for expansion when they become heated, and so prevent their cracking. Before lighting up, especially in very cold weather, it is advisable to warm gently the condenser for about ten minutes before beginning the exhibition. Also avoid any sudden rush of cold air by opening the lantern door unnecessarily during the exhibition, otherwise the lenses are likely to get broken. See, also, that a few ventilation holes are in the periphery of the cell, so as to permit the escape of any moisture which may happen to condense on the inner faces of the lenses. There are many forms of condenser in which ventilation and easy taking apart have been made special features. Fig. 59 shows an example.

In the optical lantern the transparent slide is placed immediately in front of the condenser, so that the cone of light covers the whole surface of the slide. In the cinematograph projector the tiny picture on the film is farther away from the condenser. The lantern must be placed in such a position that the diameter of the cone of light shall slightly exceed the frame opening of the gate.

Fig. 59.—Metalwork of Heavy Condenser, Detachable and Adjustable

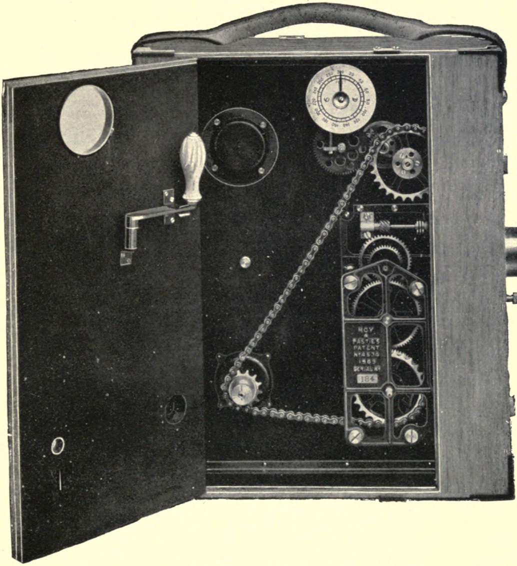
The intensity of the illumination on the screen is governed by the amount of light which the condenser first collects and then converges into the projection lens. In order to obtain this result, the projection lens must be placed nearly at one of the conjugate foci of the condenser, whilst the source of light must occupy the other.

The term "conjugate foci" needs to be explained. The tendency of rays of light from the source of illumination is to diverge from a point, and spread out in all directions. If a condenser be placed in such a position in the path of these divergent rays as to collect the whole or the greater portion of them, they will be bent in passing through the lenses of the condenser, and, passing out as a convergent beam, will be brought to a point again. These two points, namely, the point of illumination and the position when the rays of light after passing through the condenser are again brought to a point, are the conjugate foci of the condenser.

In the same way the lantern slide or the cinematograph film, and the screen on to which the picture is projected, are placed at the respective conjugate foci of the projection lens.

It is therefore clear that the correct position of the source of light, namely, its distance from the condenser, is governed by the focal length of the condenser, and also by that of the projection lens. As the position of the projection lens in front of the condenser must necessarily be moved backwards and forwards for the purpose of focusing, it follows that, when critical focus has been obtained, the source of light must be moved nearer to or farther from the condenser, in order to obtain perfect illumination on the screen. Therefore, perfect illumination is only to be obtained when the light, its conjugate point, and the projection lens are all in one and the same straight line.

The focal length of an objective or condenser is the distance at which the image of a far-off object, such as a church spire, is thrown sharply on a white card held behind the lens. The distance may be measured approximately from a point midway between the two glasses. A condenser is not fixed at its focal length from the lamp, but farther away, the distance varying with that of the



CAMERA INTERIOR, SHOWING SPROCKETS AND CHAIN-DRIVE
(*Gaumont type*)

objective. When the objective is nearer to the condenser the lamp must be more distant from the latter, and vice versa. A 2½-in. focus condenser is suitable for use with any objective that is not of unusually long focus.

As shown in Fig. 60, when the source of light A is too far from the condenser B, the rays of light come to a focus at C and diverge again before reaching the gate D, so that much light is wasted. When, however, the illuminant is brought nearer, as at E, the cone of rays is concentrated on the gate, as shown by the dotted lines,

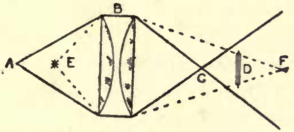


Fig. 60.—Action of Condenser in Cinematograph

and does not come to a focus until it reaches the objective at F.

The Objective, or Projecting Lens.—The brilliancy of a picture greatly depends on the first-class quality of the lenses used. Therefore, the best is cheapest in the long run. The usual form of objective or projection lens is that which is known as the Petzval type of portrait lens (see Fig. 61). In this, two sets of lenses are mounted in a brass tube. The front combination is a bi-convex crown-glass lens A, accurately ground, fitted, and cemented with canada balsam into a plano-concave flint-glass lens B, so as to form an indivisible joint. The back combination is a bi-convex crown-glass lens C separated by a narrow brass ring from a negative concavo-convex flint-glass lens D. A good quality lens of this form, while being achromatic (giving an image free from colour fringes) should give sufficient depth of definition and flatness of field. These two combinations are separated in the tube by a space about equal to their diameter.

In reassembling an objective lens, always see that the glass C has its flattest side next to the lantern, while D is placed with its concave side nearest to C, the two glasses being kept a slight distance apart by a metal ring. The third glass, a cemented combination, is properly placed as indicated. A useful rule to remember is that all external convex surfaces in a lantern objective should face the screen. When a glass has two convex surfaces, the more convex of them should face the screen.

While the ordinary cinematograph lenses are of the Petzval type, a specially designed anastigmat gives better results, owing to its finer definition, flatness of field, and equality of illumination. It is an expensive instrument.

A cinematograph objective is commonly of shorter focus than one for lantern use, since the film pictures are so much smaller than lantern slides, and could not be projected to a sufficient size with a lantern objective except by getting an inconvenient distance from the screen. On account of the degree or enlargement necessary, a cinematograph objective should be of large aperture, and capable of giving the best possible definition. The larger the diameter, the focal length, etc. being equal, the better the illumination.

Approximately, the focus of the lantern objective is about three and a half times that of the cinematograph projector lens. Thus with a 3-in. lens on the machine a 10-in. lantern objective will be required in order that the sizes of the respective images may coincide as nearly as possible on the screen. There may be difficulty in accomplishing this, and a compromise must be made (see Fig. 62). The size of the picture will depend on the distance between the machine and the screen, even with the same lens; and when a picture is too large, and neither the screen nor the machine can be moved, then longer-focus lenses must be used.

If the lenses are not marked with their focus, the latter may be ascertained by placing a sheet of white paper on the wall opposite the window, and hold-

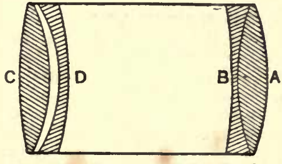


Fig. 61.—Diagram of Lenses in Objective

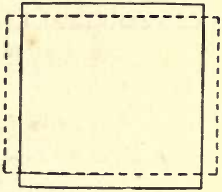


Fig. 62.—Relative Size of Cinematograph Picture (shown dotted) and Lantern-slide Picture on Screen

ing the lens in front of it, so as to show on the paper either an image of the window frame or that of some distant object. When the image is sufficiently sharp, the equivalent focus of the lens is the distance between the sheet of paper and a point on the lens, midway between the front and back combinations.

Determining Lens Required, Size of Picture, and Distance.—The equivalent focus of a lens is an important factor, for on it depends the size of the picture obtainable at different distances from the screen, and vice versa. A focus is a point from which rays of light diverge, or to which they converge.

To secure a certain size picture at a certain distance, multiply the distance the cinematograph machine is from the screen by the width of the mask opening, or the light aperture at the gate, which is usually $\frac{7}{8}$ in., and divide the product by the size of the picture required ; the result will be the focus of the lens needed. For example, it is required to find the focus of the lens which will give a 15-ft. picture at 50-ft. throw. Therefore, $50 \times \frac{7}{8} = 43\frac{3}{4} \div 15 = 3$-in. focus lens, approximately.

CINEMATOGRAPH LENS TABLE (*Gate Aperture assumed to be* 1 *in. wide*).

Distance between Projector Lens and Screen.	*Focal Length of Object Lens* — 2 in.		2½ in.		3 in.		3½ in.		4 in.		5 in.	
	Approximate Width of Picture on Screen											
ft.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	5	0	4	0	3	4	2	10	2	6	2	0
15	7	6	7	0	5	0	4	3	3	9	3	0
20	10	0	8	0	6	8	5	9	5	0	4	0
25	12	6	10	0	8	4	7	2	6	3	5	0
30	15	0	12	0	10	0	8	7	7	6	6	0
35	17	6	14	0	11	8	10	0	8	9	7	0
40	20	0	16	0	13	4	11	5	10	0	8	0
45	22	6	18	0	15	0	12	10	11	3	9	0
50	25	0	20	0	16	8	14	4	12	6	10	0
60	30	0	24	0	20	0	17	2	15	0	12	0
70	35	0	28	0	23	4	20	0	17	6	14	0
80	40	0	32	0	26	8	22	10	20	0	16	0
90	45	0	36	0	30	0	25	8	22	6	18	0
100	50	0	40	0	33	4	28	7	25	0	20	0
110	55	0	44	0	36	8	31	5	27	6	22	0
120	60	0	48	0	40	0	34	4	30	0	24	0
130	65	0	52	0	43	4	37	2	32	6	26	0
140	70	0	56	0	46	8	40	0	35	0	28	0
150	75	0	60	0	50	0	48	7	37	6	30	0
200	100	0	80	0	66	8	57	2	50	0	40	0

LANTERN LENS TABLE (*Slide Mask or Carrier Opening assumed to be 3 in. wide*)

Distance between lantern lens and screen.	*Focal Length of Object Lens* 4 in.		5 in.		6 in.		7 in.		8 in.		9 in.		10 in		11 in.		12 in.		13 in.		14in.		15 in.	
	Approximate Width of Picture on Screen																							
Feet	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	7	6	6	0	5	0	4	3	3	9	3	4	3	0	2	9	2	6	2	4	2	2	2	0
11	8	3	6	7	5	6	4	9	4	2	3	8	3	4	3	0	2	9	2	6	2	4	2	2
12	9	0	7	2	6	0	5	2	4	6	4	0	3	7	3	3	3	0	2	9	2	7	2	5
13	9	9	7	10	6	6	5	7	4	11	4	4	3	11	3	7	3	3	3	0	2	9	2	7
14	10	6	8	5	7	0	6	0	5	3	4	8	4	2	3	10	3	7	3	3	3	0	2	9
15	11	3	9	0	7	6	6	5	5	8	5	0	4	6	4	1	3	9	3	6	3	3	3	0
20	15	0	12	0	10	0	8	7	7	6	6	8	6	0	5	6	5	0	4	7	4	3	4	0
25	18	9	15	0	12	6	10	9	9	4	8	4	7	6	6	10	6	3	5	9	5	4	5	0
30	22	6	18	0	15	0	12	10	11	3	10	0	9	0	8	2	7	6	6	11	6	5	6	0
35	26	3	21	0	17	0	15	0	13	1	11	8	10	6	9	6	8	9	8	1	7	6	7	0
40	30	0	24	0	20	0	17	2	15	0	13	4	12	0	10	10	10	0	9	2	8	6	8	0
45	33	9	27	0	22	6	19	3	16	10	15	0	13	6	12	3	11	3	10	4	9	8	9	0
50	37	6	30	0	25	0	21	5	18	9	16	8	15	0	13	8	12	6	11	6	10	9	10	0
60	—		36	0	30	0	25	8	22	6	20	0	18	0	16	4	15	0	13	10	12	10	12	0
70	—		42	0	35	0	30	0	26	3	23	4	21	0	19	1	17	6	16	2	15	0	14	0
80	—		—		40	0	34	3	30	0	26	8	24	0	21	10	20	0	18	5	17	2	16	0
90	—		—		—		38	7	33	9	30	0	27	0	24	6	22	6	20	9	19	3	18	0
100	—		—		—		42	10	37	6	33	4	30	0	27	3	25	0	23	1	21	5	20	0
125	—		—		—		—		—		41	8	37	6	34	1	31	3	28	10	26	9	25	0
150	—		—		—		—		—		—		—		40	11	37	6	34	7	32	2	30	0

To find what size picture will be given with a 3-in. lens at 50-ft. throw: $50 \times \frac{7}{8} = 43\frac{3}{4} \div 3 = 15$-ft. picture, approximately. To find what distance from the screen the machine must be placed, that is, the throw, in order to give a 15-ft. picture with a 3-in. lens: $15 \times 3 = 45 \div \frac{7}{8} = 50$-ft. throw, approximately. Similarly for lantern slides: (1) $50 \times 3 = 150 \div 15 = 10$-in. focus lens. (2) $50 \times 3 = 150 \div 10 = 15$-ft. picture. (3) $15 \times 10 = 150 \div 3 = 50$-ft. throw.

In most tables, as in that given on page 84, the fact that the width of the light aperture at the mask or gate is $\frac{1}{8}$ in. less than 1 in. is ignored, the width being taken as 1 in. It will be noted that the dimensions given are, therefore, only approximate.

The Care of Lenses.—Do not clean lenses with a chamois leather; keep two old cambric handkerchiefs for the purpose. Do not touch the surfaces of the lenses with the fingers, as finger-marks leave a greasy impression, which is difficult to remove, while they may also show on the screen. Avoid unscrewing the combinations as much as possible. The inside surfaces of the lenses seldom need cleaning if the lenses fit properly in the mount. But always give the outside surfaces of the lenses of both the condenser and the objective a gentle polish before beginning an exhibition, because these surfaces, being always exposed, attract dust and moisture.

CHAPTER IX

Projection Illuminants

The Various Illuminants Compared.—The source of light in an optical lantern may vary from an oil lamp to an electric arc, but many of the ordinary lantern illuminants are far too feeble for use in the cinematograph projector. Such illuminants as the oil lamp, with its two, three or four wicks; incandescent gas, with upright or inverted mantle; and electric incandescent lamps with carbon or preferably metallic filaments, need be little more than referred to in this place; for home exhibitions they may be made to serve, but there is little of a practical nature that need be said about them. The oil lamp must be kept scrupulously clean and the charred wick be rubbed (not cut) smooth and straight; the wicks, after lighting, should be turned up slowly, and the adjustable chimney altered in height until a proper draught is obtained. The incandescent mantle is cleanlier and less "smelly" in use, but the improvement in illumination is very doubtful, and the mantle is not easily preserved entire after the one show. Electric incandescent lamps of the most modern type are convenient, but suffer from the great defect that characterises the oil lamp and gas mantle—the light rays are given off by a relatively large surface and a great proportion of them is lost, whereas if the rays were emitted by a point or spot (as in the case of limelight and the arc lamp) the condenser lenses could re-combine them into a strong beam of light. Acetylene is better than any of the foregoing, the light being more intense and the area from which it is emitted being much smaller; but still it is useless for public shows of any size, and its employment generally necessitates a generator, to which there is often objection. In the form of "dissolved" acetylene (charged under pressure into cylinders containing acetone, which is capable of absorbing relatively large volumes, acetylene being liable to explosion if compressed by itself) the gas can be used with the minimum of inconvenience but a maximum of expense. Limelight, in one of its many forms, is an excellent illuminant for both ordinary lantern and cinematograph projector, and in the case of the latter it is the only practical alternative to the use of the electric arc lamp. Limelight is produced by causing an intense flame to play upon a cylinder of lime, the heat raising a spot of the lime to brilliant incandescence. The best of all illuminants for the cinematograph projector is the arc lamp, and, needless to say, this is employed in practically all the permanent cinematograph theatres.

The British standard of illuminating power is the amount of light given out by a sperm candle $\frac{7}{8}$ in. in diameter; size, six to the pound; each burning 120 gr. per hour.

The relative values of projection illuminants are given by Molteni as follow :—

	Photometric values
Oxy-hydrogen limelight	16.6
Electric incandescent lamps—	
32 candle-power	0.68
50 „ „ vertical	0.93
50 „ „ horizontal	0.93

Electric arc lamps—

7 amperes	39.03
10 „	75.61
12 „	86.50
15 „	117.61
50 „	160.80

Illuminating power

Oxygen gas compressed in cylinders, and ordinary coal-gas, with blow-through jet	*candle-power.* 300 to 500
Both gases compressed in cylinders, with mixed jet	1000 to 1500
Injector jet	1200
Gwyer No. 1 jet	1200
„ No. 2. jet..	1600
Electric arc light	from 1000 upwards

(approximately 10 amperes will give 1000 c.p.)

For small rooms, with a disc of light on the screen up to 10 ft., with limelight, a blow-through jet; or, with the electric arc, a 10-ampere arc lamp will suffice either for cinematograph films or glass slides. For larger rooms, with a disc of light on the screen up to 12 ft., with limelight, a mixed jet will be required, or with the electric arc about 15 amperes. This amperage should not be exceeded when valuable slides are shown, because the great heat which accompanies the light may ruin them.

For halls and theatres, with a long throw and a disc of light on the screen up to 15 ft., with limelight, an injector jet should be used; with the electric arc an amperage of from 30 to 50, or even 70, with a larger arc lamp relatively, may be necessary for cinematograph films. The general rule is: Take the distance between the lamp and the screen, in yards, and add 10; the product will be the amperage required. Say the distance is 100 ft. = 33 yd. Therefore 33 + 10 = 43. Therefore 40 to 45 amperes will suffice. This is for continuous current.

But as alternating current is about 20 per cent. less in candle-power for the same amperage, one-fourth more will be required with it than for continuous current.

How Intensity of Illumination Varies with the Area of the Picture.—It will be understood from the foregoing that the greater the distance between the projector and screen or the greater the size of the picture, the more powerful must be the source of light to obtain equal intensity of illumination on the screen. But the reader must not hastily conclude that doubling the distance between machine and screen would decrease the illumination to one-half. As a matter of fact, it would decrease it to one-quarter, because the same amount of light would now have to suffice for an area four times as large as before. In other words, the intensity of the illumination is inversely as the square of the distance from the source of light. Referring to the table of distances given on p. 84, a circular picture formed at a distance of 50 ft. with a 2½-in. focus lens is 20 ft. wide; if the projector is moved back until the distance is 100 ft., the picture becomes 40 ft. wide, and its area (the important factor) has grown from, say, 300 sq. ft. to 1,200 sq. ft. The same amount of light has now to illumine four times the previous area, and it is, therefore, obvious that its intensity per square foot must sink to one-quarter of what it was before. The same applies, of course, when the size of the picture is increased by substituting a lens of smaller focal length. For double the *diameter* of the screen picture, the consumption of gas at the jet or of current at the arc lamp would be increased by four, if such a course were practicable, to obtain equal intensity of illumination.

ACETYLENE

Acetylene is a gas evolved by the action of water on calcium carbide. There are two forms of generator, one in which water drips upon the carbide, and the other in which the small lumps of carbide fall into water. The easiest to construct is the water-to-carbide style, but its disadvantage is that once gas-making is started, it is difficult to stop it until the whole of the carbide has been used or spoiled. The carbide-to-water style is more economical in use, but more expensive in first cost. Particulars of a variety of acetylene generators are given in dealers' catalogues, but the following description applies to a carbide-to-water generator of approved design, which may be made by the lanternist himself if he has some knowledge of metal working.

The acetylene generator shown by Fig. 63 is intended to carry 4 lb. of carbide, which will give, say, a 300-c.p. light for three hours or an equivalent, if there is no waste; but it can be made any proportionate larger size. The size of the generator is controlled by the number of hours the lights are to be burned and the candle-power of the burners. A usual size of burner is that consuming 0.7 cub. ft. of gas per hour, giving a 27-c.p. light. As each pound of carbide yields (actual) 4½ ft. of gas, a pound will supply one of these burners six and a half hours. Fig. 64 shows the lid or cap, which is a simple water-sealed arrangement. The depth of the annular trough into which the cap or lid drops may be 6 in., and this trough should be about half-full of water when in use, so as to provide a water seal.

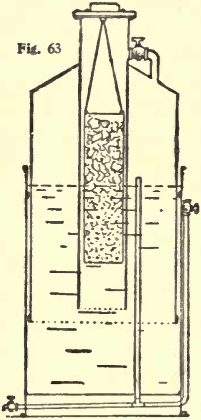
The apparatus can be made of tin or galvanised sheet-iron and painted; or it may be of sheet-zinc provided the carbide holder is of sheet-iron. The gaspipe can be iron or compo. Copper should not be used in the construction of acetylene apparatus; the use of brass is permissible, though not encouraged in the actual generating part.

The carbide holder should be of a cylindrical shape, 3 in. in diameter and 12 in. high, well perforated. The cylindrical chamber in which the carbide holder works should be 3½ in. in diameter; the lower half of the apparatus (the water tank) 10 in. in diameter and 24 in. high; the upper half (the gas bell) 9¼ in. in diameter and 24 in. high to the shoulder. The carbide holder should be suspended, so that it is wholly submerged when the gas bell is at its lowest, but should be well clear above the water when the bell is at its highest. This means arranging the suspending wires or chains so that the top of the holder is about 3 in. below the level of the shoulder of the bell.

The gas outlet pipe is usually ¼ in., but for brief high-power lights it had better be ⅜ in. The cock and short pipe A can be the same size as the gas outlet pipe. It should be explained that the purpose of the cock and pipe A, and the cylindrical chamber round the carbide holder, is to admit of re-charging (that is, withdrawing the carbide holder and replacing it) without discharging and wasting the gas in the bell. By closing the cock, communication between the bell and the generating centre is cut off; and if the lid is removed the bell is not emptied.

This is shown because the apparatus may suit some readers for a permanent purpose, as for lighting a small office, workshop, or the like ; but for temporary purposes, such as cinematograph work, the cock and pipe and the cylindrical chamber referred to might both be omitted, as no good end is served in retaining gas in the bell after

Fig. 63



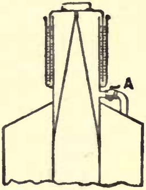


Fig. 64

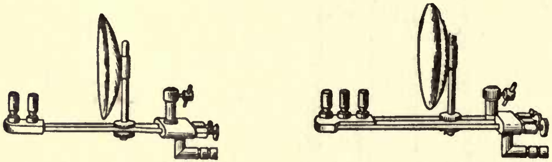
Fig. 63. — Section through Home-made Acetylene Generator

Fig. 64. — Lid or Cap of Generator

the exhibition is ended ; in fact, the apparatus is then emptied, it having to be portable in the fullest sense of the word.

For temporary work, two or three lugs or ears might be attached at the bottom of the tank, so that the base could be secured to the floor with one or two small nails or screws.

When starting the apparatus, fill the tank with water to within 3 in. of the top. Fill the carbide holder with carbide, but do not shake it down to pack close; it should be as loose as possible. Put the carbide holder in the bell, then lower altogether into the tank; but do this in such a manner that the lower part of the carbide holder only just touches the water. Gas will be immediately given off, and then the bell will sustain itself. If possible, do this all outdoors, and also discharge a little of the first gas to waste without lighting it, as the first to come away will be air and gas together, and this is an explosive mixture. This should always be



Figs. 65 and 66.—Kamm's Separate-control Acetylene Burners

done when the apparatus is charged and started after being completely empty, but is not necessary when the apparatus is in permanent use, the cock being closed when re-charging, as already explained.

It is not considered necessary to purify the gas for lantern work, as it is only in use one or two hours at a time; but for residence lighting purification is essential, for which purpose it needs to be passed through water and also, if possible, through bleaching powder (commonly called chloride of lime) mixed with coke or powdered brick, and afterwards through lime. The purification removes those properties that give acetylene its evil smell.

Compressed and Dissolved Acetylene.—The compression of acetylene is not a safe thing in the hands of any but those practised in the work or well up in the chemistry of the subject. Acetylene when compressed quickly becomes liable to explode by simple shock. The practice now followed is to compress acetylene into liquid acetone, the latter having a high solvent power, so that it is correct to say that the acetylene is dissolved in it, which gives the element of safety. To make this practicable, the steel cylinders are filled with porous inert solid material, such as fossil meal, this being saturated with acetone and the acetylene then pumped in. The latter must be properly purified beforehand. In England, the gas is compressed to not more than ten atmospheres, and the capacity at that maximum is roughly 100 cub. ft. of acetylene per 1 cub. ft. of porous material contained by the cylinder. The cylinders are in various sizes, that having a diameter of 6¼ in. containing approximately 60 cub. ft., and the 8¼ in. containing approximately 100 cub. ft. The gas, when liberated, exerts the same pressure that was employed to compress it. It comes away from the acetone unchanged in quality.

Acetylene Jets or Burners.—Three or four Bray's "Beto" burners, each taking 1 ft. per hour, make an excellent arrangement for the home cinematograph. They may be placed with the thin part of the flame facing the condenser, but many prefer the other way. The distance apart of the burners may equal their thickness, and they may be stepped $\frac{3}{32}$ in. above each other; but the stepping can be omitted if desired, simply placing them in line. It will be understood that a reflector is an essential fitting. While in most jets all the burners are fitted to one pipe, and the supply of gas is not, therefore, adjustable to each, there are some, as, for example, the Kama outfit shown by Fig. 67, in which there is a separate supply to each burner adjustable by means of a screw-down valve. In this generator, the charge, nearly 1 lb. of carbide, gives a three-hour light. If preferred, the

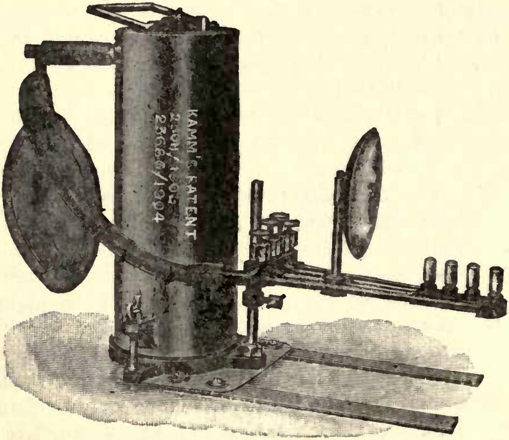


Fig. 67.—Kama Acetylene Generator

generator may be placed on the ground and connected to the jet by means of a long rubber tube. Other burners of the same make and type are shown by Figs. 65 and 66.

LIMELIGHT

It has already been shown that limelight is the best projection illuminant in the absence of the arc lamp. The equipment is reasonably cheap and the gases are generally easily obtainable. The modern system of supplying compressed gases in steel cylinders is convenient, and has advantages over the use of a generator. Of course, in villages away from photographic depots it may be more convenient to generate the gases on the spot, but the cinematograph operator has quite enough to do without undertaking further responsibilities if these can be avoided, and he is, therefore, strongly advised to leave alone the generation of gases wherever possible and to employ the compressed gas, which is readily obtainable from chemists and photographic stores throughout the land.

There are many systems of limelight, these including the oxy-hydrogen with blow-through, injector, or mixed jets; the oxy-ether, oxy-petrol, etc.; and the oxy-acetylene; and these will be described in the order in which they are here mentioned, but as limes and compressed gas are essential to all of them, these may be discussed first.

Limes.—Limelight is produced by the action of an intense flame upon a small cylinder of lime. Lime subjected to an ordinary gas flame becomes dull red-hot; but when the combustion of the gas is forced by mixing pure oxygen with the gas, the flame becomes considerably hotter and more concentrated, and the lime becomes brilliantly incandescent.

During the last few years, a better substance than lime has been introduced for the purpose. It consists of a mixture of two rare earths—thorium and cerium, put up in the form of round "pastilles"—and this mixture requires an even hotter flame than does the lime to produce its maximum incandescence, at which point it yields a light more powerful than limelight and of a colour even more suited for projection purposes. Limes are cylindrical and have a central hole through which passes a pin of the jet (see Fig. 78, p. 108). A metal strip bent to the form of tongs (see Fig. 68) is a convenient means of lifting a hot lime off the pin; when made of wire, it is also useful for clearing out the hole in the lime. Limes are sold packed in lever-lid tins containing one dozen, and also in the form of single limes each sealed in glass. The boxed limes are cheaper than the others, but the single limes are always to be preferred; should the lid of the tin be carelessly replaced so as to allow of air reaching the inside, the limes will soften and crumble. Limes are obtainable in different sizes, the smaller ones for ordinary lantern use, and larger ones for cinematograph purposes. They rapidly disintegrate when exposed to atmospheric action, and for this reason should be removed from the jet immediately a show is over, because if left till the next day they may possibly be found to have gone to pieces and have made a mess. Limes have their vagaries, some being much harder and more durable than others; some will scarcely be affected by an hour's work, and others will be pitted, cracked and worthless in less than half an hour. It is, therefore, necessary always to have spare limes at hand. The intense flame rapidly pits a soft lime, and the operator must watch for this and give the lime an occasional turn by means of the milled head and rod provided for that purpose on the jet. Should he neglect to do so, the light will decrease as the surface of the lime retreats from the flame, breaking up of the lime is rendered more likely, and the flame is liable to be deflected by the slanting surface of the pit, and may even strike the condenser, in which case a cracked lens is inevitable. Pitting is more marked in the case of the mixed than the blow-through jet.

There is a class of limes—the "Mabor"—moulded under pressure from fine magnesia powder, and these are

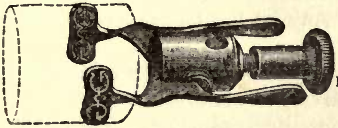


Fig. 70

Fig. 68.—Lime Tongs

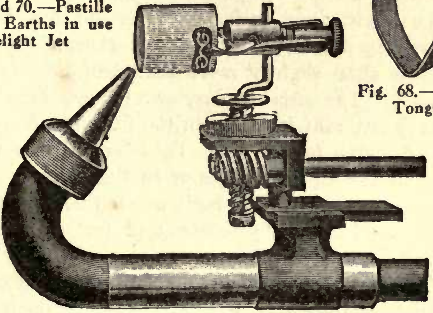


Fig. 69

Figs. 69 and 70.—Pastille of Rare Earths in use on Limelight Jet

not affected by atmosphere, are far more durable on the jet than the ordinary limes, and cost but little more.

Pastilles.—Coming now to the pastilles which in recent years have to some slight extent supplanted limes, these also are made up in the form of cylinders, but they are not bored, as they are supported by a horizontal claw or clamp, and the jet flame plays upon the flat end of the pastille (see Figs. 69 and 70). Pastilles do not deteriorate with exposure to the atmosphere, and do not pit under the action of the flame, and thus may be used over and over again up to as many as a dozen times or even more; but they require to be rubbed smooth on each occasion before use. Thus, although from eight to a dozen times the first cost of a lime, they may in the end be cheaper, and they certainly save the operator some trouble and anxiety. Any jet can be adapted to take a pastille.

Gas Cylinders.—Compressed gases are sold in steel cylinders that have been carefully annealed and thoroughly tested by the gas-compressing companies. These cylinders can withstand an internal pressure of at least 3,000 lb. per sq. in., but they are not charged to a greater pressure than slightly more than half that (120 atmospheres). The customer may own the cylinders he uses or he may pay rent for them in the form of a very slightly higher charge for the gas. Cylinders to be sent to the gas-compressing companies or to their agents should be enclosed in long, stoutly-built wooden boxes, or, instead, they may have the permanent protection of a closely-plaited hemp or coir cover.

The part of the cylinder that will give most concern to the user is the valve, a cross section through which is shown by Fig. 71. The valve is screwed into the cylinder, the gas from which leaves by the narrow passage A when the spindle B is slightly withdrawn by turning its squared portion C by means of a key; the gas passes to the lantern fittings through the inverted cone D. The gas-tight joint with the automatic regulator or reducing valve is made entirely by mechanical means, and all daubing of the screw threads with soap, grease, red-lead, etc., must be strictly avoided ; accidents have been caused in this way. The stem E of the regulator or reducing valve is itself threaded, and has an adapter F upon it. First turn the adapter until it is close to the shoulder G of the fitting. Then, without any relative movement between stem and adapter, screw the latter into the cylinder valve. In this way the cone on the end of the stem will go home into the inverted cone D of the valve. When it can go

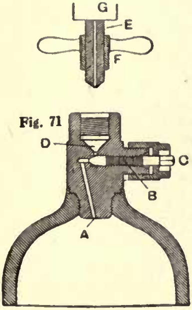


Fig. 71

Fig. 72

Fig. 71.—Section through Cylinder Valve, etc.

Fig. 72.—Combination Key and Wrench

no farther, it may be found necessary to undo the fitting by, say, the third of a turn, and then screw the adapter in as far as it will go ; before finally connecting up the rubber tubing from regulator to jet, place a thumb over the regulator outlet and gently turn on the gas to test for leakage, which will be betrayed by a slight hiss.

The valve is opened or closed by means of a box spanner with folding handle. The extra leverage when the handle is open is convenient when turning on the gas, and the reduced leverage when the handle is folded prevents the valve being strained when the gas is turned off. Occasionally the valve itself needs tightening up, and for this purpose a combination spanner of the type shown by Fig. 72 is useful.

The sizes, weights and capacities of gas cylinders are as follow:—

Overall length and diameter, in ins.	*Approximate weight empty, in lbs.*	*No. of cub. ft. at atmospheric pressure compressed into cylinder*	*Style of cylinder*
14 × 4	10	6	Seamless
19 × 4	13	10	Seamless
23 × 4	15	12	Seamless
27 × 4	18	15	Seamless
35 × 4	23	20	Seamless
36 × 5½	43	40	Seamless
50 × 5½	65	60	Seamless
32 × 7	66	60	Seamless
52 × 5½	67	60	Lap-welded
41 × 7	85	80	Seamless
68 × 5½	85	80	Lap-welded
49 × 7	103	100	Seamless
82 × 5½	103	100	Lap-welded

Pressure Regulators.—Certain fittings are necessary with these cylinders. Gas at a pressure of 120 atmospheres must not be allowed to pass unchecked to the jet, it being necessary to have some means of reducing the pressure. This reduction is generally effected by means of an automatic regulator, which may be either the Beard or duplex pattern, the former being in more general use and being shown by Fig. 73. The gas from the cylinder enters at A, and fills the bellows C, which rises against the spring S. Inside the bellows a kind of lazy-tongs arrangement of levers L is attached at D, so that the greater the pressure in the bellows the more tension is put on a cam at the other end, which presses the valve I tightly into the neck, thus stopping any further supply of gas from the cylinder entering the bellows until the pressure is reduced. On opening the jet taps the gas flows out of the outlet P, which is con-

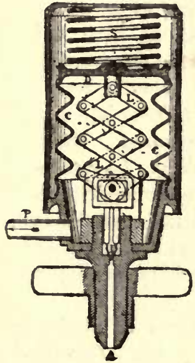


Fig. 73.—Section through Beard's Regulator

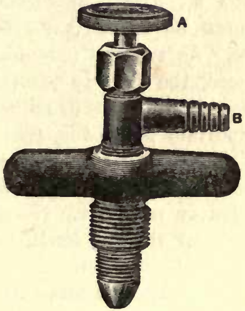


Fig. 74.—Fine - adjustment Non-automaticRegulator

nected to the jet. The spring S now forces the gas through the jet, and at the same time, the pressure of the gas inside the bellows being reduced, the lazy-tongs closes and moves the cam, which opens the valve and admits more gas into the bellows from the cylinder. These operations proceed quite automatically throughout the exhibition, and they do not require any attention whatever, the pressure of the gas always remaining the same until the cylinders are nearly empty.

A much cheaper attachment than the automatic regulator is a simple nipple, or, preferably, a fine-adjustment non-automatic regulator (Fig. 74). Either of these screws into the cylinder valve exactly in the way already described, and, in the second device, the pressure is cut down by means of a conical valve controlled by means of the milled head A, the gas passing to the jet through tube B. Either arrangement may be used for small lantern shows, but is not recommended for cinematograph use. As the gas pressure in the cylinder becomes reduced, the light is affected, and further adjustment of the cylinder valve or milled head required. There is one important point, too, that must always be remembered. When a simple nipple or non-automatic regulator is used, the adjustment must always take place at the cylinder valve or regulator. No adjustment whatever must be made at the jet itself, or the rubber tubing will be burst or blown off.

Pressure Gauges.—It will often be desirable to know how much gas a cylinder contains. Therefore, the use of a pressure gauge (Fig. 75), to be screwed into the cylinder valve, becomes necessary. The construction of a typical gauge is shown by Fig. 76, which illustrates the instrument with the dial removed. The gas passes from the cylinder up the stem of the valve and through B into the elliptical spring tube A, which the pressure tends to straighten, and in so doing operates through C the quadrant D, which engages with the spindle of the index finger (shown dotted). In the stem is a check valve F, which prevents any sudden rush of gas injuring the elliptical tube.

A very convenient form of gauge is one combined with an automatic regulator, or even with a fine-adjustment valve, the connections for which are shown in Fig. 77. It tells the operator in a moment, and while the show is in progress, how much gas he has left.

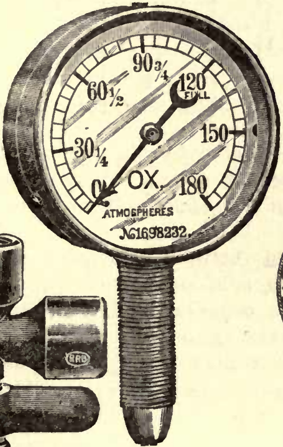


Fig. 75.—Pressure Gauge

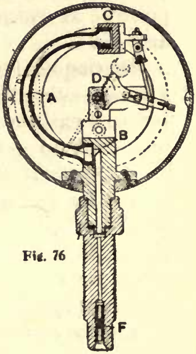


Fig. 76.—Mechanism of Gauge

Fig. 76

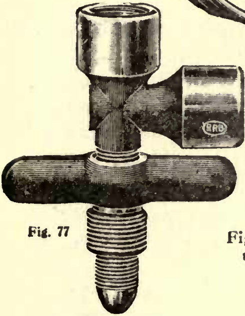


Fig. 77.—T-connection for Gauge and Regulator

Fig. 77

To read the pressure gauge, and so be able to ascertain the amount of gas in a cylinder, it should be noted that the pointer will stand at a pressure of 120 atmospheres when the cylinder is full, and at 90, 60, and 30 when three-quarters, one-half, and one-quarter full respectively, thus :—

Atmospheres.	*Size of Cylinders in cubic feet.*			
	6	12	20	40
120	6	12	20	40
90	4½	9	15	30
60	3	6	10	20
30	1½	3	5	10
15	¾	1½	2½	5
5	—	½	1	1⅔

The gas may be run out to the third of an atmosphere (between 4 lb. and 5 lb. per sq. in.), this being the lowest pressure at which a regulator will work without causing anxiety.

Distinguishing between Oxygen and Hydrogen Fittings.—Certain mixtures of oxygen and hydrogen (or coal-gas) are explosive, and it is, therefore, very important to guard against any accidental mixture of the two gases. For this reason, cylinders, regulators and gauges for use with oxygen are painted black, whereas those for hydrogen are painted red. Further, to render the indiscriminate use of the fittings, etc. impossible, those for oxygen have right-hand screw threads, and those for hydrogen left-hand threads.

Low-pressure Hydrogen.—Whilst in all forms of limelight the oxygen must be supplied under pressure, the hydrogen can be used at the low pressure at which it issues from the ordinary domestic gas fittings. (Of course, pure hydrogen is not coal-gas, but for projection purposes coal-gas is nearly always meant when the term hydrogen is used, and even when hydrogen is ordered from the gas-compressing companies, coal-gas is usually supplied.) When gas at ordinary pressures is used, the jet should be of the blow-through or injector type, as described later.

Oxygen Generators.—A word or two must be said with regard to other sources of oxygen, as a showman may be obliged at times to generate the gas on the spot. The old method was to heat a mixture of 4 parts by weight of potassium chlorate and 1 part of black oxide of manganese in an iron or copper retort, and to pass the gas which came off the heated mixture through a wash-bottle, which cooled and purified it. It then passed to a gas bag, which, when the show was in progress, was loaded with weights to produce the necessary pressure. A mixture of 4 lb. of chlorate and 1 lb. of oxide yields about 20 cub. ft. of gas. The more modern method is to use cakes of the chlorate and oxide already prepared in the correct proportions, two cakes yielding enough oxygen for a one-hour cinematograph show. One of the newest generators for use with such cakes is Kamm's; it is well made and comprises a retort heated by a methylated-spirit lamp or blow-lamp and a gas-container, in which the pressure is produced, not by weights, but by the action of adjustable springs. As the generated gas passes into the container, the latter rises and tilts the steel lever back; then, as the gas is used and the container begins to descend, a spring pulls the steel lever forward, this bringing the retort forward with it and exposing more of the cake to the action of the heat, so that before the gas stored in the container is wholly consumed there is a new supply coming from the retort.

Oxygen cakes for use in retorts are made by mixing the potassium chlorate and the manganese oxide in the proportions already stated, slightly damping, pressing into a mould and turning out, and leaving in a warm place till dry.

Generating Oxygen from Oxylith, Etc.—Oxygen may be produced in such quantities as the lanternist requires by using one of the special substances such as oxygenite or oxylith (prepared from sodium peroxide) which yield oxygen when in contact with water.

Limelight Jets.—Oxy-hydrogen limelight jets are of at least three main types: (1) the blow-through jet,

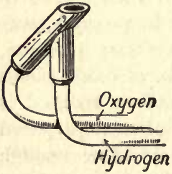


Fig. 79. — Nipple of Blow-through Jet

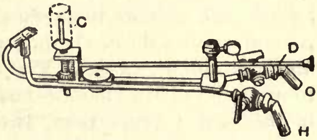


Fig. 78.—Simple Blow-through Jet

suitable for use with hydrogen issuing at low pressure from the ordinary gas fitting and for oxygen from a cylinder; (2) the mixed jet for use when both gases are under pressure; and (3) the injector (or ejector) jet for use under the same conditions as No. 1, but giving a more powerful light than the blow-through jet.

A simple blow-through jet is illustrated by Fig. 78, H and O indicating the hydrogen and oxygen nozzles, C the lime, and D the rod by means of which the lime is rotated. Such a jet is useful for general lantern work or for cinematograph projection at close quarters or for a small picture. The detail of the nipple given in Fig. 79 will suggest that the jet of oxygen is, as it were, thrust through the hydrogen flame, there being no mixture of the gases within the jet itself. This is the safest of all oxy-hydrogen jets, but also the feeblest.

The injector or ejector jet provides a means by which the passage of the oxygen under pressure induces an increased flow of hydrogen, and the two gases mix within the jet on their way to the nipple. A section through a good jet of the injector type (Fig. 80) will serve to explain the principle. Oxygen passes through the chamber A under pressure, and issues as a fine stream through the nozzle B. The low-pressure hydrogen, supplied through barrel C, fills the chamber D, and is induced to leave it by the stream of oxygen flowing from the nozzle B. The two gases mix in chamber E and then pass through the holes F F′ into G, and thence through V to the nipple H. There are various forms of this jet, but that illustrated will give a fair idea of the working principle. It should be said that occasionally the term "ejector" is applied to a blow-through jet in which the hydrogen tube is extended past the oxygen nipple—much in the way shown by Fig. 79—thus causing a slight mixing of the gases before combustion.

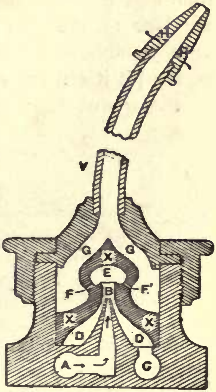


Fig. 80.—Section through Injector Jet

The simplest type of mixed jet is that shown by Fig. 81, H and O indicating hydrogen and oxygen nozzles. The gases, both under pressure, mingle in the mixing chamber

B and thence pass to the jet. The mixing chamber may be packed with metal gauze to assist the mixing action. Mixed jets are obtainable fitted with a great variety of devices to facilitate the turning of the lime; centring of the light, both horizontally and vertically; altering the distance between light and condenser and between lime and nipple; obtaining fine adjustment of the proportions of the two gases; providing a by-pass, etc. It is possible in some high-class jets to cut off the gases at the jet itself, except for a small by-pass flame, and at a subsequent time to restore, simply by turning two handles, the full light with exactly the original proportions of the two gases. Dealers' catalogues show a variety of patterns of limelight jets.

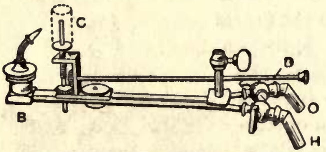


Fig. 81.—Simple Mixed Jet

A jet is supported in the lantern body on a stout upright steel pin standing in a tray, or on a plate, which slides into the body, and the jet is clamped at the required height by means of the set-screw shown in the various illustrations already given. Some trays have mechanical movements to assist in centring the light. For example, in Beard's "Biojector" jet, equally suitable for high-pressure or low-pressure hydrogen, there is a variety of movements: 1 indicates the hydrogen valve (to which the compressed hydrogen or the house gas is supplied); 2, oxygen valve, used when the hydrogen is under pressure; 3, oxygen valve, used when gas is taken from the house system; 4, cut-off lever; 5, cut-off hydrogen bye-pass adjusting screw; 6, elevating milled head; 7, lateral milled head (hidden in illustration); 8, lime-turning milled head; 9, lime adjustment to and from nipple; 10, tray to catch broken lime; 11, iron base.

Fitting up for Limelight.—First stand the gas-

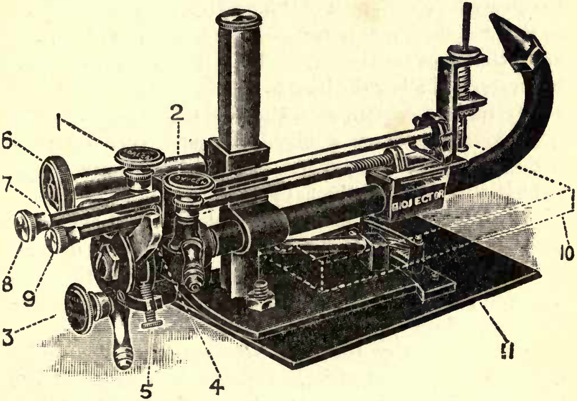


Fig. 82.—Beard's "Biojector" Combination Mixed and Injector Jet

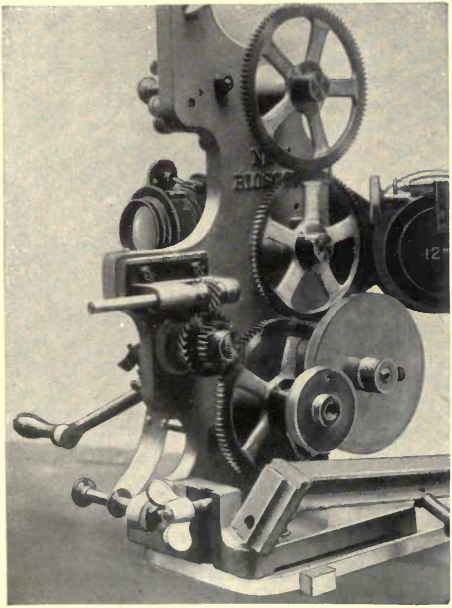
cylinders on end, and tie them to a support to prevent their falling. Do not, however, attach them to the cinematograph stand. Open the valves with the key for an instant, so that any dust may be blown out. Screw the automatic regulators into the cylinders, as already explained. Connect the regulator outlets by stout rubber tubing to the jets—usually hydrogen or coal-gas to the left and oxygen to the right-hand tubes. Both taps of the jets should be shut off.

Managing a Limelight Jet.—Select a good lime, and bore out the hole so that it may fit the pin freely. Open the valves of the cylinders, so that the bellows in the regulators may become distended. Now turn the hydrogen tap of the jet, and allow a little to escape before lighting up. Then turn on a little oxygen, just sufficient to cause a blue flame. Let it burn thus for a few minutes, so that the condenser may be warmed, and also to prevent any black spot on the lime. Then turn on a little more hydrogen and allow the lime to get thoroughly hot. Now gently turn on oxygen until the lime is incandescent, but not enough to cause a hissing sound. Turn on more hydrogen, then more oxygen, little by little, until a good light is obtained and the flame is silent.

Hissing in a good jet is caused by excess of one gas—generally oxygen—and is to be avoided, because in itself it indicates inefficiency and because it is liable to alarm nervous people in the audience. Neglect to turn the lime may also give rise to a hissing noise.

The distance of the lime from the nipple or orifice depends on the kind of jet. In blow-through jets it will be about $\frac{3}{8}$ in., and in mixed and ejector jets about $\frac{1}{8}$ in. A black spot on the lime shows that it is too near the jet. Begin with the lime well down, so that should a split occur it may still leave enough of the lime to work with, and turn it slightly from time to time, to avoid pitting, and also to prevent the flame being deflected upon and so cracking the condenser.

Having worked up a good light, insert a slide and roughly focus by means of the draw tubes, the objective or focusing tube having been racked exactly half-way out. Then withdraw the slide, and push in the jet or



PROJECTOR MECHANISM, SHOWING WORM-DRIVE AND SPUR WHEELS
(New Bioscope "Dreadnought" type)

withdraw it from the condenser, raise it or lower it, or swing it slightly to one side as may be necessary, until there is an even field of light; if the jet is not central, there will be coloration or a shadow somewhere on the screen and the jet should be moved in the opposite direction to the defect until this is removed (see Figs. 83 to 88). Three minutes' experimenting should teach all

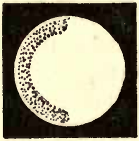


Fig. 83

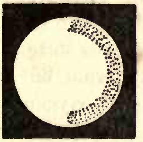


Fig. 84

Fig. 85

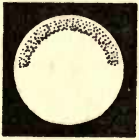


Fig. 86

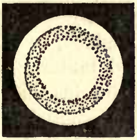


Fig. 87

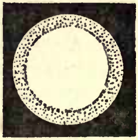


Fig. 88

Figs. 83 to 88.—Centring of Illuminant in Lantern or Cinematograph Projector

that it is necessary to know in this matter. Then insert a slide and finely adjust the focus by means of the milled head on the lens. During the show, remember to turn the lime occasionally.

Always, when turning off the light, cut off the oxygen first, as otherwise there may be a slight pop in the hydrogen tube of a mixed or injector jet.

It is wise to retain the key on the cylinder valve stem, so that in the case of a burst rubber tube or other similar accident the gas can be cut off immediately. An annoying accident is the bursting off of the string that binds the flexible bellows of the automatic regulator. Unscrew the brass cover and overhaul the binding occasionally. Should the accident happen during a show, turn off the oxygen immediately, and either re-tie the bellows with fine string or replace the regulator with an ordinary nipple or fine adjustment valve.

The Saturator or Carburettor.—This is a device which may commend itself to the operator when a supply of hydrogen in the gaseous state is unavailable. It takes a number of different forms, but in all of them the principle is that a stream of oxygen is forced through ether, petrol, alcohol, etc., vaporising the volatile liquid and passing onwards to the jet in the state of a combustible gas. There are great prejudices against the use of the ether saturator, and, indeed, in the London area its employment in a licensed building is not allowed (" ether and other inflammable liquids shall not be employed under any circumstances for producing light "—L.C.C. Regulations; 6th April, 1909), but there is a number of types which the manufacturers guarantee to be safe and reliable, and among these special mention may be made of the pendent saturator (Fig. 89), which is hung up at a distance from the jet, and is thus kept cool, the connections to the jet nozzles being from the outlets A and C. Methylated ether of about .717 sp. gr. is poured in through the opening shown closed by plug D until it overflows at E, which plug must previously have been removed. (F is another overflow plug, and through it the saturator is occasionally pumped out to keep it in good condition.) D and E are next screwed in tightly, and the oxygen cylinder connected to nozzle B, while the outlet nozzle A is connected to the oxygen side of the jet, and C to the hydrogen side. Then proceed as with the ordinary oxy-hydrogen light, noting that the valves on the saturator should be wide open and adjustments made at the jet. Saturators are liable to "pop" when near exhaustion. Should such a tendency be noted after turning off the oxygen tap of the jet at the end of a show (it is indicated by the light continuing at the jet nipple), immediately turn on the oxygen tap again fairly full, and then turn off the hydrogen tap and wait for the lime to lose its red heat. Then turn off the oxygen tap.

Fig. 89.—Pendent Saturator — the Safest Saturator

Mixed jets used with oxy-ether gas *must* have the mixing chamber packed with metal gauze.

When methylated ether (sp. gr., .717) cannot be obtained, the makers of the pendent saturator say that gasolene may be used instead, but that on no account is the use of petrol, benzoline, or methylated spirit allowable. This is puzzling instruction, inasmuch as in Great Britain the terms gasolene, petrol and benzoline are almost synonymous. The safest course, we think, is to use the methylated ether—or nothing.

There are many ethers, but the ordinary ether or ethyl oxide $(C_2H_5)_2O$ is prepared by heating alcohol with strong sulphuric acid. After drying over lime this forms a pure ether suitable for medicinal purposes. Methylated ether is made in an exactly similar manner, but from methylated spirit instead of the pure alcohol, hence it contains some of the impurities of the spirit from which it is prepared. Gasolene is the lightest portion of the petroleum distillate, boiling at a very low temperature and evaporating entirely on exposure to air. Petrol or petroleum spirit, benzoline, and benzine were one and the same. They evaporate easily, but not so quickly as gasolene. Petrol is now heavier than it used to be, the proportion of the original petroleum distilled into it being much greater since the enormous increase in price. Petrol would leave much residue, while methylated spirit would, probably, not burn in an ether saturator. Benzine or light coal-tar naphtha would suit, only that it might cause a deposit of carbon in the jet.

Oxy-acetylene Limelight.—The combustion of acetylene with oxygen, under pressure, as in the blowpipe or limelight jet, produces a temperature in the hottest part of the flame—the extreme end of the white part—of about 4,000° C., this being, probably, twice that reached in the oxy-hydrogen or oxy-coal-gas flame. As the melting point of lime is approximately 3,000° C., the use of this substance is out of the question, and it becomes necessary to employ a "pastille" of the rare earths already mentioned (see p. 99). Both the acetylene and the oxygen must be under pressure, and about equal quantities of each are used; these may be produced by generators or taken from cylinders. In a special oxy-acetylene plant on the market, the oxygen is generated with oxygenite powder (one of the sodium peroxide preparations) and the acetylene is produced by a generator. One charge (30 oz. of oxygenite) is sufficient for 90 minutes' light, at the rate of 6 cub. ft. of oxygen per hour.

CHAPTER X

The Projection Arc Lamp and its Management

Electric Current.—In buildings where electricity is laid on, a supply of current can be obtained from the company's mains by connecting two cables of suitable carrying capacity. Current is either "alternating" or "continuous." The electrical pressure or the E.M.F. is measured in "volts," and stands in a similar relation to electricity as the hydraulic force or pressure does when applied to water.

Electric current, that is, quantity flowing, is measured in "amperes." Electrical power, or the amount of electricity used, is measured in "watts." The watts are equal to the volts multiplied by the amperes, thus: 100 volts × 10 amperes = 1,000 watts, or 1 kilowatt.

A Board of Trade Unit (B.T.U.) is 1,000 watts for one hour, that is, 1 kilowatt-hour, and is the commercial unit for purposes of public supply.

Continuous current is the most suitable for projection purposes, as it gives a steady and silent arc, which is due to the current continually flowing in one direction, from positive to negative. The positive or top carbon in the arc lamp assumes a crater-like form, which is easily maintained, thereby giving a beautiful and brilliant light. Low-pressure supplies are usually 100 or 110 volts, occasionally 105 or 115; and high-pressure supplies are 200, 220, 250, 400, and 480 volts.

Alternating current is usually considered not very satisfactory for projection purposes, although it is sometimes used. The current is continually changing from one direction to another, so that it is impossible to say which carbon of the arc lamp is positive and which negative. These changes, or oscillations, vary from 40 to 120 per second, are termed cycles, alternaces, or periods, and are written thus ∿. When alternating current is used, the feeding of the carbons requires constant care and watchfulness; otherwise the light will soon dim down

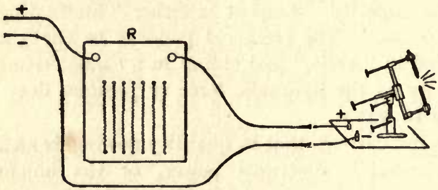


Fig. 90.—Wiring of Simple Circuit (Resistance and Lamp); Continuous Current

and go out. Besides the difficulty of keeping the light bright and steady, there is a continual buzzing sound proceeding from the arc. Low-pressure alternating supplies are usually 105, 110, and 120 volts; high-pressure 210, 220, and 440 volts.

Electrical Connections.—Arc lamps with an automatic feed are not so reliable for projection purposes as the hand-feed or Davenport lamp. The latter requires from 45 to 50 volts for its efficient working. As the supplies of electricity are from 100 volts upwards, it is clear that some sort of apparatus is required to choke down, reduce, or regulate the extra voltage—to put the brake on, in a sense. With continuous current this is done by using a rheostat or resistance, which is composed of a number of coils of german-silver or other wire attached to a frame and arranged in such a manner that, by shifting the regulating key, the current is caused to pass through a greater or lesser number of the coils.

In connecting the cables from the mains, the positive

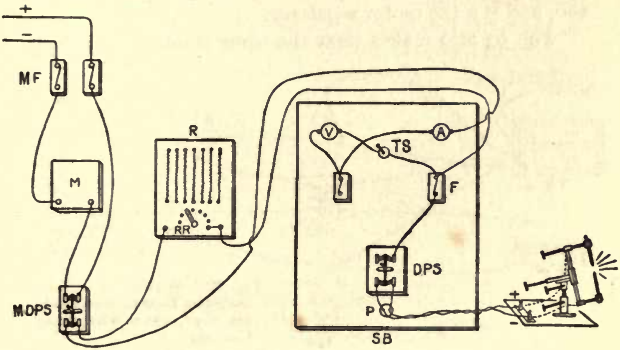


Fig. 91.—Wiring of Circuit including Switchboard; Continuous Current

wire or lead should be taken first to the resistance and then to the arc lamp. From the other terminal of the lamp, the negative wire or lead goes straight to the main, as in Fig. 90. Other apparatus may be included in the circuit for greater economy, safety, and convenience, and these will be described later (see Figs. 91 and 92). With alternating current, a transformer and a choking coil are used in place of an ordinary resistance (see Fig. 92).

In the illustrations above-mentioned, A is the ammeter, F the fuses, D P S the double-pole switch, E S the electric supply from mains, M the meter, M D P S the main double-pole switch, M F the main fuses, P the plug, with flexible cable to arc lamp, R R the resistance regulator, T S the tumbler switch to voltmeter, V the voltmeter, T R the transformer, P C the primary coil (210 volts), S C the secondary coil (105 volts), T F the twin flex, P L the pilot light, S B the switchboard, A C the arc lamp, C C the choking coil, and M R the motor regulator.

Fig. 93 also makes clear the connections for a simple

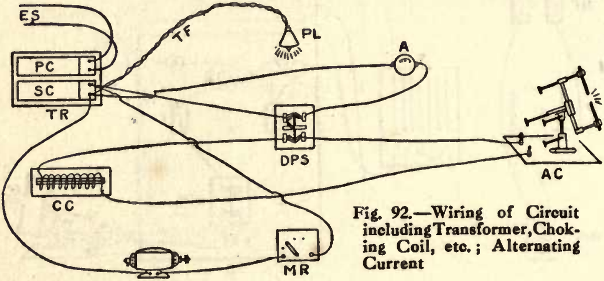


Fig. 92.—Wiring of Circuit including Transformer, Choking Coil, etc.; Alternating Current

circuit, M being the main leads, V the voltmeter, R the resistance, A the ammeter, and L the arc lamp. The voltmeter is in "parallel," while the ammeter and resistance are in "series."

Fig. 94 shows a model lay-out or wiring diagram for a two-machine plant, as actually installed by the Walturdaw Company in a number of electric theatres. A three-wire service from the public main is indicated, and there is a motor-generator to deal with an alternating-current supply. The change-over switch puts 400 volts on to the motor side of the motor-generator.

or it puts 200 volts only through a resistance across the lantern arc. There is a throw-over switch to put distributor pressure on the motor or on the primary of a static transformer; another throw-over switch takes current for the lantern from the generator or from the secondary of the transformer.

Resistance to the Electric Current.—All substances offer some resistance to the passage of a current of electricity, although some—notably the precious metals, copper, aluminium, etc.—allow it to pass more readily

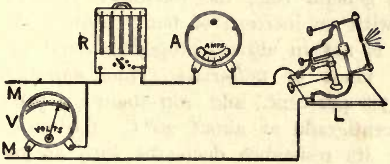


Fig. 93.—Wiring of Simple Circuit with Voltmeter in Parallel and Ammeter in Series; Continuous Current

than others. Early in the nineteenth century Ohm, the scientist, discovered that the strength of a current of electricity through any circuit varies directly as the pressure of the E.M.F., and inversely as the resistance. This has since been known as Ohm's Law of Resistance. In other words, the current yielded by any cell, battery, dynamo, or other generator varies directly as the difference of potential between the poles, and inversely as the resistance through which the current has to pass. This fact is expressed by the now well-known formula $C = \frac{E}{R}$, C being current in amperes, E pressure in volts, and R resistance in ohms.

The unit of measurement is called an "ohm." For instance, the resistance of a mile of No. 20 gauge copper wire is practically 41½ ohms, or 2.3579 ohms per 100 yards.

The resistance of a uniform wire varies: (1) Directly as its length, or proportional to its length (the longer the wire the greater the resistance); (2) Inversely as its sectional area, or inversely proportional to its cross section (the thicker the wire the less the resistance); (3) Directly as the specific resistance of the material of which it is made.

As a general rule, the resistance of materials increases with an increase of temperature; the rate of increase is not in direct proportion, and varies with different kinds of materials. Thus annealed copper alters 0.388 per cent., and iron about 9.5 per cent. per degree centigrade at about 20° C. Carbon is an exception; its resistance decreases with an increase of temperature.

To overcome the resistance to the flow of current along a conductor energy must be expended; this energy is usually wasted, and appears as heat at the surface of the conductor. The amount of current flowing is not diminished, but a loss of pressure results.

Ohm's law enables this loss of voltage to be calculated if the resistance of the conductor and the value of the current in amperes are known. Thus the volts lost are equal to the amperes multiplied by the resistance expressed in ohms. For example, a current of 20 amperes is made to flow through a wire which has a resistance of 4 ohms, and the voltage required to send the current against the resistance will be $20 \times 4 = 80$, the voltage required. This pressure of 80 volts will be lost in the wire, and if the current is to do work after passing through the conductor, additional voltage will be necessary.

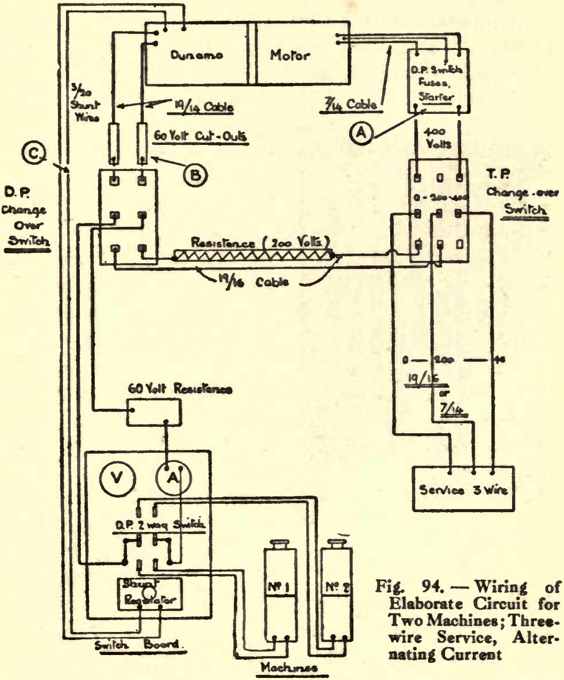


Fig. 94. — Wiring of Elaborate Circuit for Two Machines; Three-wire Service, Alternating Current

If only 10 amperes are to flow through the circuit, then the voltage lost will be 10 × 4 = 40 volts lost in the conductor; then a total of 40 + 50 = 90 volts only would be required to work the projector. Thus the voltage lost in a given wire will vary according to the current flowing along that wire.

Ammeters and Voltmeters.—The ammeter, amp-meter, or ampere-meter is an instrument by means of which the flow of an electric current can be measured. It is constructed in the simplest form possible in order that it should not be affected by any heating of the coils which measure the current during the passage of electricity. An electro-magnet is placed so that its magnetism increases proportionally to the amount of current passing, the result being shown by means of a needle working over a dial which carries a graduated scale in amperes. Some kinds are made for use with "continuous" current only, while others may be used with either "alternating" or "continuous" currents. It should be remembered that ammeters are always placed in *series* with the other main appliances in the circuit, as shown in Figs. 91 to 93.

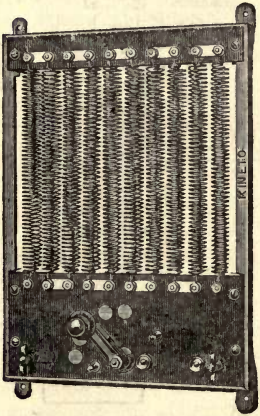


Fig. 95.—Usual Type of Resistance or Rheostat

The voltmeter or voltameter is an instrument by means of which the intensity of the pressure is measured. Its construction is similar to that of the ammeter, but the windings of the electro-magnet are of finer wire, and consequently of a higher resistance. Hence the voltmeter takes very little current. It should be remembered that a voltmeter is always placed in *parallel* with the other main appliances in the circuit, as in Figs. 91 to 93.

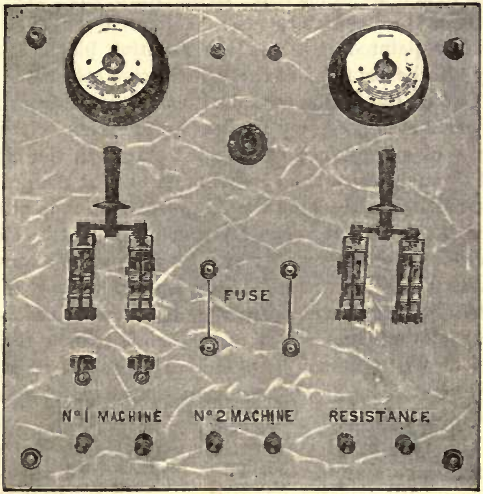


Fig. 96.—Switchboard, showing Instruments and Switches

Determining Positive and Negative Poles.—It has been shown that the positive lead should be connected to the upper carbon of the lamp. When there is doubt as to which wire or lead is the positive and which the negative, simply place the two ends in a glass of water, switch on the current, and notice which cable gives off bubbles of gas. That is the *negative.* Then connect up accordingly.

The positive terminal of a dynamo, battery, or other electrical apparatus, the polarity of the terminal of which it is essential to know, is usually marked with plus sign, thus +, or it is painted red. In the case of large secondary batteries (accumulators) the positive terminal is invariably painted red, and the negative black. Cables may also be obtained of these distinctive colours.

Use of the Resistance or Rheostat.—In working a projector it is necessary to absorb the excess voltage by means of a resistance or rheostat placed in the circuit, and through which the current must pass at the pressure required before reaching the lamp in which it is utilised. Thus, if the current varies, the resistance must be altered accordingly, or the number of volts will not be a constant quantity. It is, therefore, not correct to say that a certain resistance will absorb so many volts unless the number of amperes which will be made to flow through it is also determined. An ordinary form of resistance is illustrated by Fig. 95, while a typical switchboard is shown by Fig. 96.

The amount of energy lost, expressed in watts, in sending a current through a resistance can be calculated by the following formula: the current multiplied by itself and multiplied by the resistance. Taking the previous examples, in the first case the wasted energy is $20 \times 20 \times 4 = 1{,}600$ lost watts. In the second case, $10 \times 10 \times 4 = 400$ lost watts.

The resistance is placed in the circuit chiefly for regulating the flow of current required for the arc lamp. It is, therefore, clear that the amount or flow of current will be increased proportionately as resistance is switched out of circuit, and decreased as resistance is switched into operation. Resistances are constructed to suit either low or high voltages.

A combination resistance which will cut out 250 volts is, perhaps, the most convenient, as it takes up very little more space than one which might be found on occasion to be too small. A combination resistance is so arranged that only half the coils are in use when on low voltage, whereas all the coils are available when on

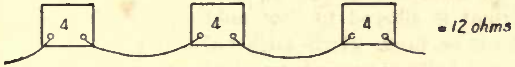


Fig. 97.—Resistances Connected in Series

Fig. 98.—Resistances Connected in Parallel

Fig. 99.—Resistances Connected in Series-parallel

high voltage. It has three terminals; one is a neutral for both low and high voltage, and the others are respectively for whichever voltage is required.

In a large hall connect the cables to the main fuses. In a small hall, or in a room, say, of a house, connect the cables to the bus-bars of the distribution board. In any case see that the cables and fuses are of the sizes required to carry the current.

The fuse is a safety device which breaks the circuit.

It consists of a wire or number of wires forming part of the circuit, and of such size and material that they melt and perish when subjected to an electric current almost powerful enough to damage the lamps and other apparatus in the circuit.

Having wired up the outfit, be careful at first to cut out almost the whole of the current when "striking the arc" (see p. 140), and only gradually switch out the resistance, and thereby increase the current as required and as notified by the ammeter, but never to the maximum amount that the wires will carry. If too much current is allowed to flow suddenly, the fuse may be blown or fired, which might also put out the lights in the hall. Always have some fuse wire at hand in case of such an emergency. In a large hall the lights would, of course, be on a separate circuit from that of the projector.

In determining the amount of resistance required in a circuit containing a hand-feed arc lamp working a projector, care should be taken that the rheostat is sufficiently large for the purpose, otherwise the resistance coils will become too hot. To prevent this, and where a large resistance is not available, it is sometimes preferable to use two or more small rheostats connected together in parallel, so as to disperse the heat over a greater area, and thereby keep the resistance coils cooler than if only one small rheostat were used. The key of only one rheostat should be used for regulating the current.

In connecting up rheostats in series, the total resistances in ohms are added together (see Fig. 97). In connecting up rheostats in parallel, the total number of ohms is divided by 4, in accordance with Ohm's law, the resistance of a conductor, neglecting temperature effects, is directly proportional to its length, and inversely proportional to its cross sectional area (see Fig. 98). It may be necessary on occasion to connect up rheostats in series-parallel (see Fig. 99).

When the hand-feed arc lamp is working normally, that is, when the carbons are an average distance apart, its resistance is about 2 ohms. This lamp requires about 50 volts for its efficient working. This voltage with the lamp resistance of 2 ohms would give a current of 25 amperes according to Ohm's law ($25 = \frac{50}{2}$). But as the tips of the carbons burn off, and the space between them increases, the resistance also increases until it becomes so great that no current will pass, and the arc goes out. While, on the other hand, at the time when the arc is "struck" (see p. 140), that is, when the carbons are touching, the resistance is practically nil, which allows an abnormal amount of current to pass, thereby practically short-circuiting the system.

To find the resistance in a circuit, divide the voltage by the amperage. The result will be the amount of resistance expressed in ohms.

$\text{Ohms} = \frac{\text{volts}}{\text{amperes}}$ or $R = \frac{E}{C}$; 110 volts ÷ 30 amperes = 3.666, approximately $3\frac{1}{2}$ ohms.

An arc lamp requires a certain definite voltage; if of open type about 45 volts, if of enclosed pattern about 80 volts.

An ordinary incandescent lamp (metallic filament) of 16 c.p. supplied with current at 200 volts pressure takes a current of about $\frac{1}{4}$ ampere = a consumption of 50 watts.

$200 \div \frac{1}{4} = 50$. The same lamp at 100 volts takes $\frac{1}{2}$ ampere, which is also = 50 watts. $100 \div \frac{1}{2} = 50$. An arc lamp, such as is used for street lighting, takes about 8 amperes. A small electric fan motor, with a 12-in. diameter fan, takes about $\frac{1}{4}$ ampere, at 200 volts = 50 watts. Therefore, one could be worked by connecting it to an ordinary incandescent lamp socket. A 10-h.p. electric motor takes about 50 amperes when working at full load from 200-volt mains.

The voltage or pressure of the E.M.F. is found by multiplying the amperage by the amount of resistance in ohms. $V = A \times O$.

How many volts are needed to send 20 amperes through 10 ohms? If the circuit included a back E.M.F. of 40 volts, how many volts would then be required? Answer: $20 \times 10 = 200$ volts, with no back E.M.F., and $20 \times 10 + 40 = 240$ volts, with a back E.M.F. of 40 volts.

A difference in potential (P.D.) between two points gives rise to an electrical pressure, or E.M.F., from one to the other of them. Hence, if two bodies at different potentials are placed in electrical communication with each other, this difference of potential will give rise to an electric current flowing from the one at the higher to the one at the lower potential.

What is the P.D. at the terminals of a dynamo which sends 50 amperes through 20 ohms? Answer: $50 \times 20 = 1{,}000$ volts = P.D.

What horse-power is needed to run a 65-volt 10-ampere arc lamp? Answer: 1 h.p. = 746 watts. $65 \times 10 = 650$ watts. $\therefore X = \frac{650}{746} = \frac{325}{373}$ h.p., or nearly 1 h.p

The ampere is the unit of flow, or the measurement of current. One ampere of current would result from 1 volt of pressure of the E.M.F. passing through a resistance of 1 ohm.

Generally speaking, to find the amperage, that is, the amount of current in a circuit, the voltage is divided by the resistance, expressed in ohms. $\therefore A = V \div O$; or $A = \frac{V}{O}$. Thus a 20-h.p. dynamo is running at 500 volts. What current is it yielding? Answer: $20 \times 746 =$

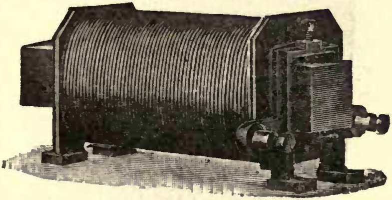


Fig. 100.—Choking Coil

14,920 watts. $14{,}920 \div 500 = 29.84$, or nearly 30 amperes.

Again, what amount of current is being used by an arc lamp working a picture projector from 110-volt mains with a 4-ohms resistance in the circuit? Apparently, the answer would be $110 \div 4 = 27.5$ amperes. But this is not correct, because the resistance of the lamp has not been taken into consideration.

If, then, according to Ohm's law, two places between which there is a P.D. of 1 volt are connected by means of wire, of such a resistance that its resistance plus that already existing between the places is 1 ohm, a current of 1 ampere will flow through the entire circuit. Therefore, in the above example the resistance in the circuit is 4 ohms plus the resistance of the lamp, which is 2 ohms. $\therefore 4 + 2 = 6$ ohms, the total resistance. Hence, $110 \div 6 = 18.333$ amperes is the correct answer. In other words, 110 volts at the mains — 50 volts absorbed by the

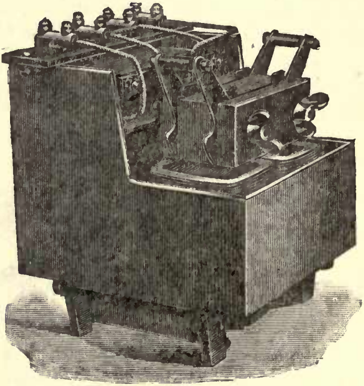


Fig. 101.—Combined Transformer and Choking Coil

lamp = 60 volts, which is the P.D. And $60 \div 18.333 = 3.272$ ohms.

What is the resistance of a glow lamp which takes .2 ampere at 100 volts, and what horse-power does it use? Answer: $100 \div .2 = 500$ ohms. $\therefore .2 \times 100 = 20$ watts $= \frac{20}{746} = \frac{10}{373}$ h.p.

What resistance must be put in series with a 45-volt

10-ampere arc lamp so that it may be run from 65-volt mains? Answer: Volts across resistance = 65 − 45 = 20. Current through resistance = 10 amperes. ∴ 20 ÷ 10 = 2 ohms resistance.

The Use of a Choking Coil.—In Fig. 92 (p. 120) there is no resistance indicated, in its place being a choking coil C C. This is a coil of copper wire wound round a soft iron core, *without* direct contact. When an electric current is passed through the wire the core becomes magnetised, and a secondary electric current is induced which flows in the opposite direction. Such a coil is used in "alternating" current working, in place of a resistance, in connection with a transformer. Its induction is great compared with its resistance, and its advantage over a simple resistance lies in the fact that it absorbs but little power, whereas the resistance uses up, in the form of heat, the power not taken by the lamp, much of the current being thus wasted, but having to be paid for all the same. A choking coil saves nearly all this waste, which is otherwise dissipated by a resistance as heat, and soon reduces the cost of the bill for current. A choking coil appears to push back the current, or hold it back, until required by the lamp. Fig. 100 shows such a coil, and Fig. 101 a coil combined with a transformer.

Electrical Conductors.—In column 1 of the tables on p. 134 is given the size of conductor in common use. Thus 7/16, 19/17, and 225/40 mean that these cables are composed of seven wires of No. 16; nineteen wires of No. 17; and 225 wires of No. 40 standard wire gauge respectively.

In column 2 is given the maximum current permissible in conductors laid in casing or tubing, provided

CARRYING CAPACITY OF CABLES = 1,000 AMPERES PER SQUARE INCH.

Size S.W.G.	*Amperes.*	*Volt drop.*	*Size S.W.G.*	*Amperes.*	*Volt drop.*
3/25	2·5	15	7/19	15·0	24
3/24	2·9	16	7/18	21·0	25
3/23	3·3	17	7/17	27·0	26
1/18	4·2	18	19/20	29·0	27
3/22	4·2	18	7/16	33·0	28
7/36	4·9	18	19/19	35·0	28
3/21	5·3	19	7/15	40·0	29
1/17	5·4	19	19/18	47·0	30
7/24	5·7	19	7/14	48·0	30
3/20	6·4	19	19/17	60·0	32
7/23	6·6	20	19/16	75·0	33
1/16	6·8	20	19/15	91·0	35
3/19	7·6	20	19/14	108·0	36
1/15	8·2	21	37/16	130·0	37
7/22	8·5	21	19/13	136·0	38
1/14	9·8	21	37/15	157·0	39
3/18	10·3	21	37/14	187·0	40
7/21	11·0	21	61/13	350·0	47
7/20	13·0	22	91/12	625·0	51

CARRYING CAPACITY OF CABLES (FLEXIBLES) = 1,000 AMPERES PER SQUARE INCH.

Size S.W.G.		*Amperes.*	*Volt drop.*
35/40	= 1/22	1·7	15
36/38, 23/36	= 1/20	2·6	16
70/40	= 1/19	3·2	16
64/38, 40/36	= 1/18	4·2	18
136/40	= 1/17	5·4	19
114/38, 70/36	= 1/16	6·8	20
225/40, 90/36	= 1/15	8·2	21
178/38, 110/36	= 1/14	9·8	21

CAPACITY OF FUSING CURRENT IN AMPERES.

Size of Wire S.W.G.	*Copper.*	*Aluminium.*	*Lead.*	*Tin.*	*Alloy (Lead 2, Tin 1).*
40	3·41	2·52	0·46	0·55	0·44
39	3·84	2·84	0·52	0·62	0·49
38	4·76	3·52	0·64	0·76	0·61
37	5·74	4·25	0·77	0·92	0·74
36	6·79	5·03	0·92	1·09	0·87
35	7·88	5·83	1·06	1·26	1.02
34	9·04	6·68	1·21	1·44	1·16
33	10·2	7·55	1·37	1·64	1·31
32	11·5	8·5	1·55	1·84	1·48
31	12·8	9·47	1·72	2·06	1·65
30	14·1	10·4	1·9	2·27	1·82
29	15·5	11·4	2·11	2·52	2·02
28	18·4	13·6	2·48	2·96	2·37
27	21·5	15·9	2·89	3·45	2·76
26	24·7	18·3	3·33	3·96	3·18
25	29	21·4	3·9	4·65	3·73
24	33·4	24·7	4·5	5·36	4·3
23	38·1	28·2	5·13	6·1	4·9
22	48	35·5	6·46	7·69	6·17
21	58·6	48·4	7·88	9·4	7·54
20	69·9	51·7	9·41	11·2	9
19	81·5	60·3	10·9	13	10·4
18	107	79·7	14·5	17·2	13·8
17	132	98	17·8	21·2	17
16	166	122	22·3	26·6	21·3
15	198	146	26·6	31·7	25·4
14	232	171	31·2	37·1	29·8
13	286	212	38·5	48	37·8
12	344	254	46·3	55	44·3
11	—	300	54·5	65	52·2
10	—	347	63·2	75	60·5
9	—	—	75·4	90	72·2
8	—	—	88·3	105	84·5
7	—	—	102	121	98
6	—	—	116	138	111
5	—	—	134	160	128
4	—	—	165	197	158
3	—	—	174	204	167
2	—	—	200	239	191
1	—	—	221	263	211
0	—	—	254	303	243

the external temperature does not exceed 100° F (37.9° C.).

In column 3 is given the total length in yards of the conductor, "lead" and "return," for one volt drop, when the current in each conductor is that as given in column 2.

The Fuse.—This has already been mentioned. Electrical circuits and the appliances therein should be protected by a fuse wire or other cut-out, such as the

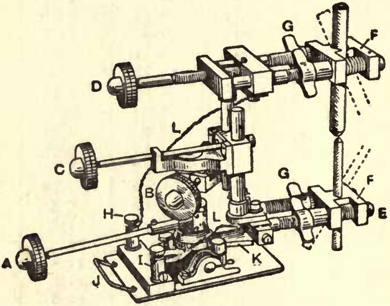


Fig. 102.—A Widely-used Type of Hand-feed Arc Lamp

magnetic circuit-breaker, which will automatically open the circuit should the current attain such abnormal dimensions as are liable to injure the appliances or the circuit.

The fuse is the most elementary form of cut-out. It usually consists of a few inches of wire, of a less carrying capacity than the circuit wires, and its destruction by the current means the other parts of the circuit have been saved from injury and danger. In selecting a fuse it is necessary to take into account the overload time element or time-lag and the liability to oxidation as well as the fusing capacity—that is, fusing current—inasmuch as a certain period of time elapses before the fusing current can raise the temperature of the metal to the melting point.

In determining the relative sizes of fuse wire to be used on the several parts of a circuit, it is important that the fuses should be so arranged that in the event of a short-circuit or fault on any branch or sub-circuit, the fuse protecting this branch will blow before the main fuse, as otherwise current will be cut off from the whole installation until the main fuse is replaced. By employing copper for the main fuses and tin or lead for the sub-circuit fuses, this may generally be prevented. It is inadvisable to use as fuses wires of a larger gauge than about No. 13 S.W.G. Above this size, strip fuses are preferable; or, failing this, several strands of a smaller gauge wire may be connected in parallel and so made to serve the purpose.

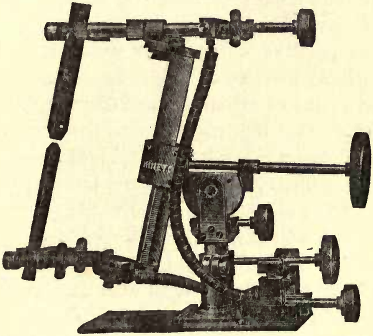


Fig. 103.—Kineto Arc Lamp (Carbons arranged for Continuous Current)

The Electric Arc Lamp.—The discovery of the electric arc is generally attributed to Sir Humphry Davy, the English scientist, who found that a continuous discharge of electricity across an air gap separating two carbon pencils connected to the poles of an electric generator produced light of dazzling brilliancy. The name *arc* is suggested by the curved form which the current here takes, as it leaps across from point to point. The arc itself produces only about 5 per cent. of the light, the negative carbon 10 per cent., and the "crater" in the positive carbon the remaining 85 per cent. The carbons wear away as the light continues, and there must be means of bringing them closer together. In arc lamps for general lighting purpose the means is automatic, but for projection work the hand-feed arrangement is preferred. The ordinary hand-feed arc lamp is shown by Fig. 102. A is the elevator to raise the lamp; B the traverser for lateral adjustment; C the hand-feed for "striking the arc" and feeding the carbons; D the top arm carbon adjuster; E the bottom arm carbon holder; F the jaws to hold the carbons; G the winged nuts to tighten the jaws; H the positive terminal for "lead" to the top or positive carbon; I the negative terminal for "lead" to the bottom or negative carbon; J the handle to draw or push the lamp in or out; K the clamp to alter the angle of the lamp; and L an asbestos-beaded cable leading from terminals to the top and bottom arms of the lamps. The mechanism is insulated by plates of mica in between the parts, to prevent short-circuit.

Up-to-date arc lamps of reliable types are shown by Figs. 102 to 106. In the third of these figures, 1 indicates clamping screw for upper carbon; 2, clamping screw for lower carbon; 3, carbon feed; 4, vertical adjustment of arc lamp; 5, lateral adjustment; 6, angular adjustment, for tilting lamp; 7, longitudinal adjustment of upper carbon; 8, lateral adjustment of upper carbon; 9, screw for advancing entire arc lamp;

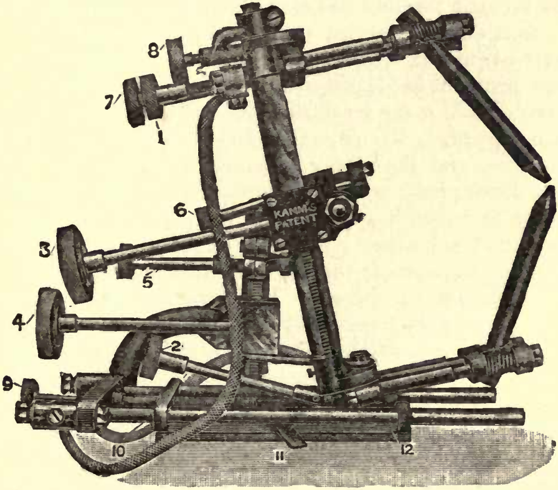


Fig. 104.—Kamm's Universal Arc Lamp (Carbons set for Alternating Current)

10, parallel rods sliding in sleeves on tray; 11, fixing lever for tray; 12, adjustable tray.

Carbons should be fine grained and of the best quality, in order to give a good and steady light. Common quality carbons are generally of coarse grain, and are often the cause of a poor and unsteady light. The arc is "struck" by turning the milled head C (Fig. 102) sharply to the right and then to the left. This brings the carbons into momentary contact together, and then separates them to a short distance, thus forming the arc. Some knack is required to do this smartly. The carbons must be brought together and then immediately separated by a short distance varying according to the strength of the current, as the ordinary voltage used in practice is insufficient to force the electricity to jump across any considerable space separating the carbons. When these are separated, the current meets with very great resistance, and the energy expended in overcoming this resistance produces a high degree of heat, which is sufficient to vaporise a portion of the carbon; the gases produced are better conductors of electricity than the air, and thus permit the current to flow across the space between the two carbons. The current in passing from the positive to the negative detaches minute particles of solid carbon, which strike back with immense velocity upon the positive carbon, their impact being so great as to raise a portion of that carbon, the "crater," to a white heat. The temperature of the crater is the highest known to science, as far as practical production by artificial means is concerned, and is sufficient to melt even the diamond, which is the hardest and most refractory substance known. This high temperature produces an immense volume of light from a very small spot, and it is upon this fact that the use of the electric arc in cinematograph projection depends. The greater the efficiency of the working of the lamp, the whiter the light and the better for projection purposes.

If the carbons are new, allow them to burn a few minutes before starting the projection, so that a good crater may be formed on the top carbon, and to give the light time to settle down steadily and to become quite silent.

It is seldom necessary to look into the lantern to see

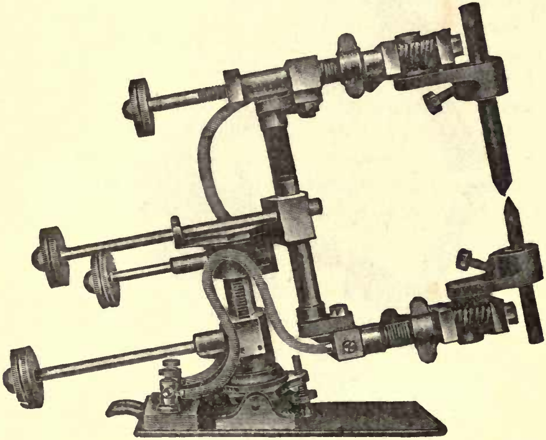


Fig. 105.—Walturdaw Arc Lamp with Special Carbon Adapters

if the carbons are all right. Watch the gate, and notice if it is well covered by a bright disc of white light, having a thin bluish tinge at the top. This bluish tinge gradually widens as the carbons burn away and the light begins to dim down. Consequently, a very slight adjustment of the hand-feed C (Fig. 102) will be needed to maintain a good light.

When the disc of light on the gate falls down, or goes to one side, use the elevator, or the traverser, as the case may be. A little practice will enable the operator to judge of the condition of the light, by the illumination on the gate, as before indicated, and so save his eyes from the glare of light inside the lantern.

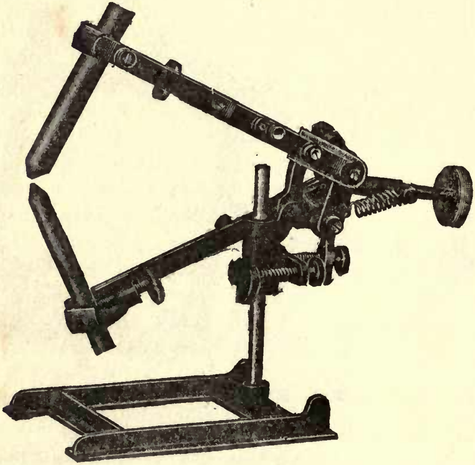


Fig. 106.—Beard's "Ideal" Arc Lamp (Carbons arranged for Alternating Current)

If the crater formed on the upper carbon is too small, the shadows are too sharply contrasted and do not merge into the high lights in a gradual or natural manner. In a life-like picture the shadows gradually blend into the high lights, and the image appears to stand out in relief from the flat surface upon which it is projected. This effect is readily seen in a good half-tone photograph, whereas a pen-and-ink drawing of the same picture appears as a flat surface, owing to the shadows being sharply defined. The size of the crater depends upon two factors: (1) The strength of the current, or amperage, and (2) the length of the arc. The length of the arc is practically proportional to the voltage, for a given current, and the size of the crater increases proportionally with the length of the arc. Hence, expert operators advocate the use of the high-voltage carbon for cinematograph projection, instead of the ordinary soft low-voltage carbon, which produces such a small crater that the shadows in the picture are too sharp. An increase of from 5 to 8 volts is just sufficient to produce the blending of the edges of the shadows necessary to give the most life-like picture. Other advantages are:—(1) The arc being longer, less attention is required to prevent the tip of the lower carbon from getting in the way of the light from the crater of the upper one; (2) the high-voltage carbon burns away much less rapidly, and the arc need not be adjusted so often; while (3) there is a considerable saving in the amount of carbon used, up to about 50 per cent.

When using alternating current, a larger disc of light on the gate will be necessary. The carbons will also need more frequent adjustment, this being necessary whenever the arc hisses. When the light is correct, there is only a slight buzzing sound, to which the operator will soon become accustomed.

Carbons for Continuous Current.—The sizes of carbons for continuous current are as follow (25 mm. = 1 in.):—

5 to 10 amperes,	7 mm. solid	and	10 mm. cored.		
10 to 15 ,,	10 ,,	,,	,,	13 ,,	,,
15 to 25 ,,	12 ,,	,,	,,	16 ,,	,,
25 to 30 ,,	13 ,,	,,	,,	18 ,,	,,
30 to 40 ,,	14 ,,	,,	,,	20 ,,	,,
40 to 50 ,,	16 ,,	,,	,,	22 ,,	,,
50 to 60 or more up to 120 ,,	18 ,,	,,	,,	25 ,,	,,

The top carbon is cored, and is larger than the bottom one, which is solid. They are usually placed at an angle of about 30°, and with the front sides in line with each other, while the ends are about $\frac{1}{8}$ in. apart (see Fig. 107).

Carbons for Alternating Current.—The sizes of carbons for alternating current are:—

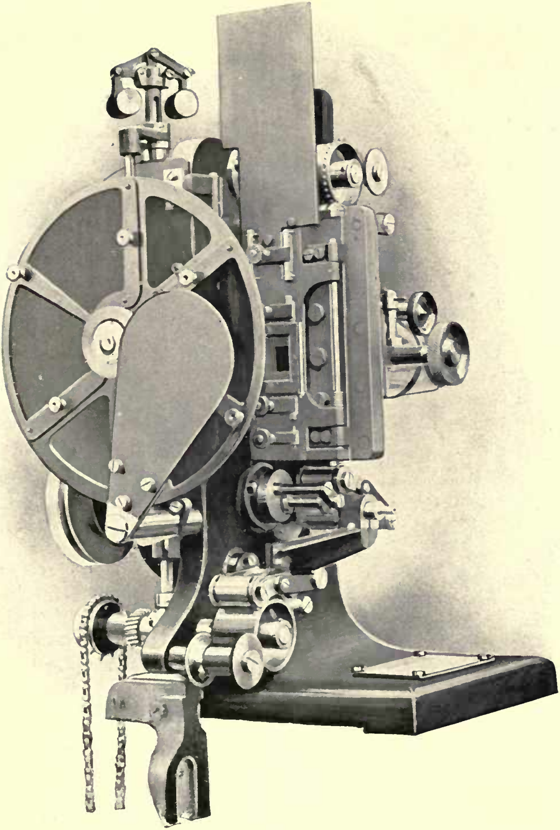
10 to 20 amperes,	13 mm. cored.		
20 to 30 ,,	16	,,	,,
30 to 40 ,,	18	,,	,,
40 to 50 ,,	22	,,	,,
50 to 60 upwards ,,	25	,,	,,

Both carbons are cored, and of the same size relatively according to the amperage.

D-shaped carbons are the best, as they give a better light than the ordinary cylindrical shape. The latter, however, are improved by rasping away the front side a little. They may be placed in an upright position, and with the ends almost touching (see Fig. 108).

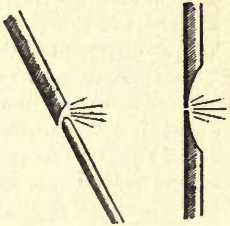
Other arrangements of carbons are illustrated by Figs. 109 to 111.

Dynamos and Motors.—The dynamo is a machine for producing an electric current by means of mechanical



KINEMACOLOR PROJECTOR MECHANISM

power, that is, for converting energy from a mechanical into an electrical form by the use of electro-magnets. Practically, the terms dynamo and motor may be explained together, as almost any dynamo properly connected to a source of electrical energy will run as a motor, and almost any motor suitably driven by a prime mover will generate electrical current as a dynamo. The dynamo is not a source of power in itself, but is merely the means by which mechanical or electrical energy is transformed, just as in a motor, where, the operations being reversed, electrical energy is changed into mechanical power. The transformation is not effected without loss of energy. Whether as a dynamo or as a motor this loss is about 20 per cent., which is equivalent to an efficiency of 80 per cent. for either machine.



Figs. 107 and 108.—Carbons for Continuous and Alternating Current respectively

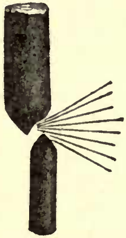
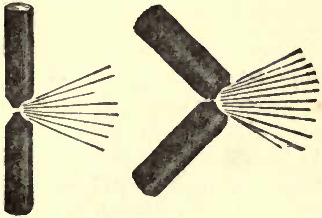


Fig. 109.—Arrangement of Carbons for Continuous Current



Figs. 110 and 111.—Arrangements of Carbons for Alternating Current

The operation of either a dynamo or a motor depends upon the fact that a bar of iron having a coil of insulated copper wire wound round it becomes a magnet when a current of electricity is passed through the said wire. This arrangement is also used in many other kinds of electrical appliances, such as electric bells, induction coils, the solenoids of arc lamps, telephones, etc. But in the dynamo and the motor two other facts are utilised, namely :—(1) The magnetic force induced in the bar of iron radiates the space surrounding the ends or poles of the iron bar, and takes a more or less circular direction from one pole to the other. This is termed the magnetic field, and when the intensities of different magnetic fields are compared they are said to have so many lines of magnetic force to the square inch. (2) When a conductor is so arranged as to cut through the lines of magnetic force, an electric current passes along the conductor in a definite direction.

The existence of the magnetic field can be exhibited in the following simple manner (see Fig. 112) :—Place a magnet between two pieces of wood upon a table, in such a manner as to support a sheet of thin cardboard. Sprinkle a thin layer of iron filings on the cardboard, when, by gently tapping it with the finger, the filings will arrange themselves in symmetrical form along the magnetic lines of force. It will be found that the lines start from one polar region of the magnet and return by curved paths to the other polar region of the magnet, through which they may be supposed to be continued. These curves do not cross or merge into one another, but are closed curves of the lines of magnetic force. These lines are more crowded in places near the poles than in other parts of the field, and where they are closest together the strength of the field is the most intense. This magnetic figure may be permanently fixed by using cardboard which has been soaked in melted paraffin wax and dried before being sprinkled with the iron filings. When these are in position pass a Bunsen flame gently over the cardboard so as to melt the wax, which on cooling again will retain the filings in position.

In a dynamo a number of conductors, suitably arranged in what is termed the armature, are revolved between the poles of one or more electromagnets, thereby cutting the lines of magnetic force and causing a current of electricity to flow along the conductors in the armature and pass on to the commutator, from which it is collected by the brushes and then led away by the cables to wherever the current is required.

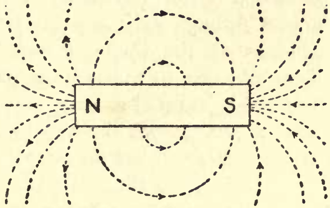


Fig. 112.—"Field" of Magnet

In a motor, the above operations are reversed, the current being led to the commutator and passing along the windings of the armature to the field magnets, where a strong magnetism is induced.

It is convenient to assume that the direction of the lines of magnetic force point towards the S or negative pole of the magnet, and from the N or positive. It is also well to remember the first law of electricity and of magnetism, namely, that *like* polarities *repel,* while *unlike* or *opposite* polarities *attract* each other. Bearing these points in mind the operations in connection with the working of dynamos and of motors become simplified. When that part of the armature which at a given moment is magnetised with *similar* magnetism to the field magnet behind it is driven forward because it is *repelled* by it, it is simultaneously *attracted* by the magnetism of the field magnet before it. The opposite part of the armature is also affected in precisely an opposite manner, and the moment the current flows the armature tends to revolve. Therefore, if the electricity flowed through only one particular coil and was never interrupted, the armature would come to rest with its poles adjacent to the *opposite* poles of the field magnet. The commutator, however, ensures that as soon as the current has passed through any coil of the armature, which consists in all machines of a number of coils of copper wire, it is shut off from that, and caused to flow through a second, and in turn a third and fourth coil and so on. The effect of this is that the armature is constantly being attracted on the one side and repelled on the other, with the obvious result that it is revolved with extreme rapidity.

The most simple form for a commutator consists essentially of two contact pieces, turning with the armature, and connected respectively with the extremities of the coil of wire ; the current is carried away by the fixed brushes. The position of these brushes should be such that they pass from one contact piece to the other at the moment when the current is reversed. Theoretically, the brushes should press against the commutator at points diametrically opposite to each other, the line joining these points being at right angles to the line joining the north and south poles of the field magnets. But practically, it is found that the field of the armature itself distorts the field of the field magnets more or less, with the result that, to prevent excessive sparking, the brushes have to be twisted round in the same direction as the armature is moving. The angle which the brushes must make, and which depends upon certain variable conditions, is spoken of as "the lead of the brushes."

Portable Petrol-driven Dynamos.—The operator knows the dynamo best in one of two forms: (1) a gas-engine-driven stationary dynamo, and (2) a portable lighting set, including a petrol engine and slow-speed dynamo. One of the plates to this book illustrates such a set. It represents a $3\frac{1}{2}$-h.p. water-cooled petrol engine with circulating pump and magneto ignition, mounted on a steel girder frame and coupled with a "Fulmen" 1,500-watt 4-pole dynamo, wound for 50 volts × 30 amperes, and over-compounded by 5 per cent. The speed at full load is 900 revolutions per minute. The dynamo has self-oiling bearings. The two steel girders forming the foundation are of H section, 5 in. by 4 in., held rigidly together by $1\frac{1}{2}$-in. steel distance pieces, which are extended beyond the clamping nuts to form axles for the trolley wheels. The dynamo and engine bed are bolted directly to the joists, keeping them true and out of twist. It is not necessary to plane the bed-plate or joists, but the shafts are lined up approximately true, any slight inaccuracy being taken up by the flexible coupling. This consists of several thick leather washers pierced with eight $\frac{3}{8}$-in. holes, with which engage four projecting pins equally spaced on both flanges of the half coupling and interleaving. The drive is practically rigid to torsional stresses, but flexible to lateral and bending effect, as the pins slip in or out of the holes slightly, thus relieving the bearings of any strain. The front of the trolley is fitted with a detachable drawbar ; the complete set without tanks weighs 8 cwt. Of course, much more powerful sets are obtainable. For example, with a 6-h.p. engine the corresponding dynamo would give 65 volts 55 amperes, of which, say, 40 amperes might be required for the projector arc, the remaining 15 amperes being usefully employed in lighting two 7-ampere " Flame " arcs for the hall, or, if metal filament lamps are preferred, in supplying the necessary current for thirty lamps of 16 candle-power each.

When lubricating motors and dynamos, always use a copper oil feeder, because ordinary tin (iron) ones are liable to be attracted by the field magnets, and many serious accidents have thus been caused. For the same reason do not leave any tools near the machine, especially while it is running.

Motor-generator.—This electrical machine is useful for reducing the voltage of the supply in an economical manner. When current at a given pressure is supplied to the motor, the electrical power is converted into mechanical power, which in its turn is utilised to drive a dynamo from which current at the desired pressure is obtained. A motor-generator set is a combination of motor and generator, or dynamo, whose shafts are generally direct-coupled, the whole being supported on one bedplate. If the motor be an " alternating " current one, and the generator, or dynamo, be a " continuous " current machine, it is clear that alternating current will be transformed into continuous current. Its efficiency is the relation of the generator output to the motor intake, and is about 50 per cent.; thus for an output of 60 volts 50 amperes, the consumption is 6 kilowatts.

Rotary-converter.—This is used for "continuous" current only, and is a modification of the motor-generator. In it the functions of the motor and generator are carried out by only one machine, which has two commutators—one at each end—one of which receives the current from the mains, while the other gives the low-voltage supply A 60-volt 50-ampere (3,000 kilowatt) machine has an efficiency of 75 per cent., the consumption being about 4 kilowatts.

Auto-converter.—This also is used for "continuous" current only. It is self-contained, as the name implies, with one armature, one commutator, and one set of brush gear, a shunt regulator also being used in conjunction for raising or lowering the secondary voltage. Its efficiency is about 90 per cent., with an output of 60 volts 50 amperes, equal to a consumption of about 3.35 kilowatts.

Transformer.—This is an apparatus for causing an "alternating" current at a certain pressure to give rise to an induced "alternating" current at a different pressure, or vice versa. A circuit containing one is shown by Fig. 92. It changes the voltage but not the nature of the current, which will still be alternating and of the same frequency as before. It has already been shown that in order to convert alternating to continuous current an alternating current motor must be coupled to a continuous current dynamo (see under the heading "Motor-generators").

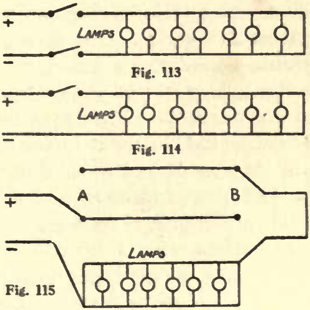
The action of a transformer depends upon the fact that if a considerable length of thin insulated wire is wound closely around a coil of thick insulated wire, and an alternating current at a high pressure be passed through the coil of thin wire, an alternating current of lower pressure will pass round the coil of thick wire when its ends are connected together. These conditions obtain in a "step-down" transformer.

On the other hand, if an alternating current of low pressure be sent round the coil of thick wire, an alternating current of higher pressure will be forced round the coil of thin wire when its ends are connected together; this gives the "step-up" transformer. To strengthen the field, a series of laminated plates of soft iron are adjusted in a suitable position. A 60-volt 50-ampere transformer has an efficiency of 97 per cent., its consumption being 3.7 kilowatt.

Transformers are also called static transformers, as they have no rotating parts.

Switches.—The wiring diagrams already given include some switches, the principal kinds of which are:—

The "tumbler," for controlling incandescent lamps, either singly or in groups, on the smaller or branch circuits. On larger circuits, containing arc lamps, etc., heavier switches of the knife or chopper type are used. It is evident that a single-pole switch will only make or break electrical continuity in one wire of the circuit, hence the conductors, lamps, etc., are still at the potential of the circuit, and in the event of a fault developing there may be a considerable leakage of current to earth (see Fig. 113). With a double-pole switch, however, electrical continuity is made or broken on both the "lead" and the "return" wires; hence the current is effectually cut off from the conductors on the farther side of the switch, and the lamps, etc., may be adjusted without any fear of a shock (see Fig. 114). It is customary for the auditorium lights to be controlled not only from the operator's box, but also from the manager's office, or some other easily accessible place near the entrance to the hall. For this purpose, "two-way" switches are used; but these are not "double-pole" switches. In Fig. 114 a group of lights is shown which are controlled by a double-pole switch; whereas in Fig. 115 a similar group of lamps is shown which are controlled by two-way switches. In the position shown the lamps are out. When the manager, at A, decided to light up the hall before the entertainment started, he would simply throw over his switch to the other side. Then, when the operator entered his box, at B, and was ready to begin the show, he (the operator) would simply throw over his switch to the other side, and so extinguish the lamps. Or, vice versa, the lights being out, the operator could switch on the lights at once. Thus, perfect control of the auditorium lights is assured from two different points.



Figs. 113 to 115.—Single-pole, Double-pole, and Two-way Switches

CHAPTER XI

Screens

LANTERN or cinematograph screens are either transparent or opaque. The former are used only when the pictures need to be projected from the back. Opaque screens should be as impervious to light as possible, and at the same time should preserve the brilliancy of the projected light without undue diffusion. Good materials are stout twill and linen sheetings, both of which may be had woven in one piece and without seams. Both kinds are improved by a good coat of whitewash slightly toned down with a little blue or black mixed in. A black sheet placed immediately behind the white one is also thought to be an improvement.

A good composition for dressing a flexible screen is: glycerine 1 lb., white glue 1 lb., french zinc oxide 2 lb., hot water 1 gal. This is applied hot to the stretched material. A sheet so prepared will roll readily without cracking, but it is doubtful if it will stand folding. Another, but somewhat troublesome, method of gaining portability is to dip the sheet in weak whitewash before stretching it, rinsing it out in water at the close of the performance, when it may be folded and wrapped in a waterproof covering.

For a perfectly opaque screen, a stout, dead white paper, pasted over heavy sheeting and well whitewashed when dry, answers excellently.

The best screen of all is a smoothly plastered wall, either distempered as before explained or painted with aluminium paint.

In a regular picture hall, that portion of the wall upon which the picture is to be projected should be recessed about 1 ft. or 1 ft. 6 in., and the sides thereof splayed, somewhat like the bevel of an ordinary picture frame. Outside of this bevel a 1-ft. unburnished gilt frame should be fixed. The inner sides of the frame and the bevelled wall should be painted black, with a matt surface, right up to the edge of the picture, or covered with black velvet. Outside the frame, dark curtains tastefully arranged add greatly to the effect of the pictures, and also reduce the reflection of light in the vicinity. The general scheme of colouring throughout the hall should be a warm tone of red, but never white, if first-class pictures are to be shown.

Likewise, if the pictures are to have a natural appearance they should not be too highly magnified, as they often are, even in so-called first-class shows. A 20-ft. to 24-ft. picture, with figures in the immediate foreground, is anything but natural in appearance, owing to the giant-like magnification of the said figures on the screen. The same film projected as a picture 12 ft. by 9 ft., or 14 ft. by 10½ ft. at most, would have a much better effect, besides requiring less current to illuminate it.

Silver screens are produced by coating with aluminium paint or by means of special patented methods, of which the following, quoted from patent No. 17,276 of 1912, is typical. Material with a painted or enamelled surface is used, such as "carriage roofing," that is, cotton cloth or canvas coated with white paint or enamel, similar to the material used to cover eating-house tables. On the painted or prepared side of this is applied clear size or varnish, or even a solution of isinglass, in a smooth coating, and before the adhesive has time to set, finely powdered aluminium, or a light metallic powder, is sprayed over the surface. When dry the surplus powder is lightly brushed off. The silver paint sold for picture frames, etc., is not suitable; but a satisfactory commercial liquid is "Reflex Silver Dressing."

For daylight cinematograph projection a linen or calico sheet may be rendered transparent by wetting, but a more effective way is to use rather coarsely ground glass mounted in a frame. The sides of the screen facing the audience must be shielded all round by wings painted black, so that the screen forms, as it were, the bottom of a large box stood on edge. The cinematograph lantern must also be enclosed at the back of the screen, to exclude all extraneous light from the rear. With such an arrangement daylight exhibitions may be given.

For special effects, there is what is known as the aerial screen. The "Bruce" aerial screen consists of a white lath, turning on a vertical axis in a plane parallel with the lantern lens and in front of a black velvet screen or background, which absorbs all rays of light not falling on the lath. The chief object of this form of screen, which is used principally for still slides, is to bring about relief, but naturally a full stereoscopic effect is not obtained in this way. Another form of aerial screen consists of a column of vapour rising from the ground and acting as a reflector of the projected rays of light, but it is only useful for producing weird effects, in which absolute definition is not a necessity.

By means of the "invisible screen," it is possible to produce aerial images or spectra in combination with real actors. A method of reflection somewhat similar to that used in the old illusion known as "Pepper's Ghost" is adopted, and it is thought that the well-known "Kinoplastikon" illusion at the Scala Theatre, London, was worked on this principle. Fig. 116 shows, in vertical section, an arrangement which is the subject of a patent granted to Oskar Messter, in 1910. The invisible screen A, preferably of plate glass, completely fills the stage opening B. In the stage floor is an opening C, under this a projecting surface or lens D, and under this again, at the proper angle, is a mirror E (either flat or concave), upon which the cinematograph pictures are projected from the lens F in the usual way. It has been stated that, to produce the "Kinoplastikon" illusion, two projecting machines with films taken to give a stereoscopic or solid effect are used. The scenery, suggested at G, is real, and the pictured actors seem to be actual people occupying that part of the stage indicated at H.

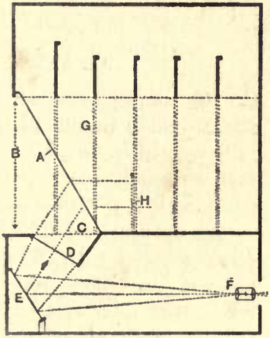


Fig. 116.—Arrangement for Producing Aerial Image

CHAPTER XII

Operating the Projector

On the management of the light it is unnecessary to say anything in this chapter, the subject having been fully treated in Chapters IX. and X. The operator must take care that his kit of tools and accessories is complete, and that it is periodically and systematically overhauled.

An operator's kit will include: A piece of felt, or other woollen material, about ½ yard square; 1 doz. resist surface slides, with writing needle; 1 bottle of fine lubricating oil; refined black-lead; vaseline; motor grease; beeswax; a 3-in. steel L-square; twine; strong pocket-knife; 2 hammers; 4 screw-drivers; bradawls; gimlets; scissors; 3 saws—hand, tenon, and hack; 1 cold chisel; 3 firmer chisels, ¼, ½, and 1-in.; fuse wire; lead clippings; 1 brace and set of Jennings' twist bits; 6 files—flat, round, triangular, etc.; 1 rasp; pliers—large and small; 2-ft. rule; tape measure; geared drill and set of bits; 2 punches; ordinary oil-can; copper oil feeder; various size screws, washers, and wire nails; film-mending machine; acetate of amyl (or film cement) and brush; small painter's tool; stiff toothbrush; dusters; old cambric handkerchiefs; wood bobbins and plugs; rubber tape; rubber solution; Blackley tape; a "Tinol" blow-lamp and soldering set, or similar set; copy of Cinematograph Act, 1909; copy of L.C.C. Regulations.

The following requisites are additional for limelight: 2 Beard's gas regulators; 2 fine adjustment valves; 1 doz. hard and 1 doz. soft limes; several feet of ⅝-in. best black rubber tubing; several feet of ⅝-in. best red rubber tubing; 2 folding keys and 1 spanner, for gas cylinders; 1 cylinder of oxygen gas; 1 cylinder of coal-gas; brass connectors, adapters, and clips; lime borer and tongs; gas pliers; lead washers; screw eyes; small 1 and 2 sheaf pulleys; strong picture cord; 2 gas pressure gauges; sets of lenses, for both slides and cinematograph films; set of lengthening tubes; copy of L.C.C. limelight regulations; plain glass slides, masks, and binding papers; slide boxes, etc.

Centring the Light.—Whether a limelight jet or an electric arc lamp be used, always centre the light before threading the film in the machine. Set the light so that it evenly illuminates the gate. Now look at the screen. If the light is too near the condenser, the screen will not be brightly illuminated, and there will be dark blue clouds on some portion of it. Draw the jet or the lamp back a little until the light on the screen is more equally distributed. If the light on the screen is brilliant, but fringed with orange-coloured edges, the light is too far away from the condenser. An orange-coloured edge on one side only, or at the top or bottom, indicates that the jet or the lamp is displaced on one side, or is too high or too low respectively (see illustrations on page 113). Centre accordingly.

When the light is correctly centred, see that the automatic safety shutter and the cut-off are both in place before putting the spool of film on the machine. Careless operators centre the light after having put the spool of film on the machine, with the result that more than one disastrous fire has occurred through the loose end of the film having fallen down, and so received the heat rays during the process of centring the light.

Winding the Film.—Be sure that the film is correctly wound on the upper spool; that is to say, the pictures must be upside down, and the last one wound on to the spool first, so that the full spool will have the first picture at the beginning of the film when commencing. And not only that, the gelatine side of the film must always be inwards and towards the light when threaded in the machine; the shiny side of the film will consequently be towards the screen. Otherwise the pictures will be reversed on the screen, and all the lettering of the titles will read backwards, while the people in the pictures will be left-handed. There is no exception to this rule when pictures are shown in front of the screen.

Of course, with a transparent screen and the machine behind it, the film must be reversed accordingly, in order to show correctly. However, the usual way, and the best, is to show the pictures in front of the screen, which always gives better results.

Threading the Film.—Having centred the light correctly and closed the cut-off, place the full spool on the upper arm of the machine, and draw off about 1 yd. of film for threading through the apparatus (see Figs. 117 and 118), as follows:—Thread the film round the roller A. Then round and under the sprocket-wheel B, seeing that the perforations are properly engaged in the pins, and the film is kept on the sprocket-wheel by the double roller C of the cradle. Open the door of the film trap D, place the film in the groove, leaving a slack loop E above it. Shut the door and see that it does not jam the film, which must work freely. Then pass the film round the dog movement F. Leave sufficient slack to pass round, without too much strain, when the eccentric roller or beater is down. Some machines are without roller A, and the film passes direct to the sprocket-wheel B.

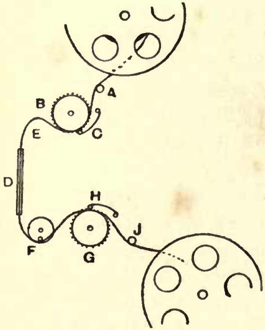


Fig. 117.—Threading Film for "Dog" or "Beater" Movement

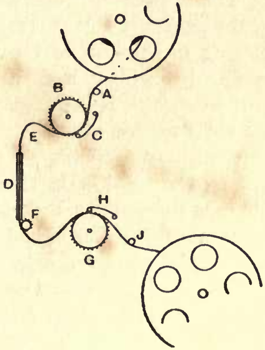


Fig. 118.—Threading Film for Maltese Cross Movement

In Fig. 118 the film on emerging from the trap D is passed round the Maltese cross movement sprocket-wheel F, and a slack loop left below it. In both cases the film is now passed over the bottom sprocket-wheel G, taking care that the perforations are properly engaging the pins, and the film is kept in position by the double rollers H of the cradle. Then pass it under the roller J when so fitted, and on to the hub of the bottom spool, where it is secured by the brass clip. Give the bottom spool one or two turns so that the end of the film may be secured firmly by one or two laps on itself. There is an improved attachment in which the end of the film is gripped by a clip on one end of a flexible band of leather, while the other end of the band is fastened to the hub of the spool.

The "Take-up" Mechanism.—The reliable working of the projector also greatly depends upon the take-up or driving mechanism of the bottom spool. In the older make of machines a spring band is used to drive the bottom spool. It is sometimes rather difficult to get just the right tension of this spring band to suit the condition of the grooved wheels on which it runs. Any dust or grit on the band or in the grooves of the wheels would increase the pull on the film, while a drop of oil might cause a slip, which would prevent the take-up acting sufficiently. Besides, when the take-up spool has only a few coils of film wound on, the pull on the film is greater than when it becomes full. Hence the tension on the spring band must be adjusted to suit both conditions. This is very important, because if not thoroughly attended to it may be found that, after having proceeded with the exhibition for a minute or two, the film has not taken up on the bottom spool. Consequently there may be either a few yards of loose film on the floor, or else making its way through the projection opening of the box or chamber. Should this occur, stop at once by cutting off the light before proceeding to adjust the take-up. If necessary, switch on the auditorium lights, and begin again. On the other hand, if the tension is too great it may cause harder work in turning the handle, and any excess of strength might damage the perforations of the film (see also p. 73).

In the newer make of machines, the take-up spool is driven by gear chains and bevel wheels, which are more satisfactory. It is also important to see that the spring rollers on the spool boxes, where the film runs between, act properly, and are kept free from dust and oil.

Masking and Projecting.—When threading the film, always endeavour to frame the picture at the gate correctly, in order as far as possible to avoid using the masking adjustment handle, which racks the film up and down. Practice will enable this to be done without any difficulty. It is certainly better to show a complete picture, with little or no perceptible racking movement, on the screen at once, than the halves of two pictures which require racking up or down, and then up or down again or down and up, until they are correctly framed. Avoid slovenliness and slipshod ways in this as well as in other matters. Generally speaking, each new film will require a little re-masking as it comes into view, because they sometimes vary in make, or there may be a slight shrinkage due to temperature effects.

At the end of the picture, as soon as the film leaves the spool box and before it reaches the gate, simultaneously close the cut-off, and stop turning the handle. At the same moment the automatic safety shutter should fall into place, and so effectually cut off both the heat and light rays emanating from the lantern.

Turning the handle should be done from the wrist only, and not by moving the arm. The movement must be perfectly smooth and regular, and without the slightest degree of thrust or pull on the handle. Avoid machines with long handles, as these require too much arm movement, which is not comfortable, especially in long shows. Besides, a short handle, worked from the wrist, must of necessity run the machine more smoothly than if a long one were used. Insist upon a short handle being substituted for the long one, whether there is an electric motor to do most of the work or not. Experience is the best teacher in this, as well as in other matters.

When two or more pictures are wound on the same spool, it is usual to cement about 12 in. or 18 in. of white or plain film in between each picture, so as to form one continuous band of film, and also to indicate the end of the picture. At the end of the first picture, pause a few seconds before proceeding with the second one, and likewise with any others that may be on the same spool.

When the last picture on the first spool has been shown, switch on the auditorium lights for the interval. Also switch off the lantern arc lamp. During the interval open both spool boxes, take off the lower spool, which now holds the pictures that have been shown, and place it in the carrying box outside the operating box or chamber; see that the box is closed and in a place where its contents cannot be interfered with. Take the empty spool off the top arm, and place it on the bottom one. Put the next full spool of pictures which are to be shown, and which have been correctly wound previous to the beginning of the show, on the top arm, and proceed to thread in the film as before. When ready, having "struck the arc" again, see that all is in order to proceed with the next spool, switch off the auditorium lights, and project the films as before.

Reducing Flicker. — Steady pictures depend on two conditions, a perfect film and a perfect machine, including the stand. Without a perfect film no machine will project a steady picture; while, on the other hand, with the most perfect film obtainable, a steady picture cannot be projected on the screen without a machine that is thoroughly accurate in all its vital parts and most rigidly supported by a well-made stand. For instance, the slightest movement or vibration of the machine or its stand will be magnified 10,000 times on the screen. An error of even $\frac{1}{5000}$ in. in the adjustment of either the film, the sprocket-wheels, or the Maltese cross movement, will produce with a 6-in. focus lens an unsteady or dancing movement of the picture on the screen to the extent of approximately 1 in. at a distance of 100 ft. Hence it will be obvious that the naturalness of the image on the screen will greatly depend on the accuracy and steadiness of the machine, and the constant and regular speed at which the film is passed through a properly illuminated gate.

As a rule, the higher the speed the less is the flicker. But the flicker, consequent on the rapid substitution of one picture for another, must be reduced to a minimum. In order to reduce flicker and a misty appearance of the image on the screen, a revolving shutter is used, as already explained, which automatically cuts off the light as each picture is moved into view, and then allows the light to pass and illuminate it before again cutting off the light for the moving into view of the next picture.

Revolving shutters are of as many different makes as the various opinions of their several advocates. In the older make of machine the revolving shutter is placed in front of the projection lens. In this arrangement the ratio of light, or exposure of the picture, is equal to about 50 to 55 per cent. as compared with a duration of darkness or non-exposure on the screen, equal to about 45 to 50 per cent. A greater exposure than the above with the ordinary disc-type shutter would be at the expense of brilliancy, and would blur the picture or destroy its sharpness, on account of the film being exposed during the period of movement. This may occur through the incorrect adjustment of the revolving shutter, or by the bad construction of the shutter itself, which opens and closes the light aperture across its diagonal or greatest length, which is about 1⅛ in. from corner to corner (see Fig. 119).

Again, a long-focus lens must be farther away from the film than one of short focus; hence the revolving shutter in front of the lens must be adjusted accordingly. To do this, loosen the set-screw on the hub of the shutter, take the shutter off the spindle, and replace it reversed. Thus the extra length of the shutter collar will give the necessary adjustment required by the longer-focus lens. In the case of a very short focus lens it will be necessary, in order to obtain the best result, to push the lantern closer up behind the machine.

Should the violet gelatine blade, if one is fitted, become broken, it is always advisable to replace it with a new one, because it cannot be gainsaid that by its use flicker of the picture is greatly reduced.

In a large number of modern machines the revolving shutter is placed behind the projection lens and nearer the gate. This position is, from an optical point of view, the correct one, because it more nearly approaches one of the conjugate foci of the beam of light transmitted by the condenser. Besides, the revolving shutter, being smaller and opening and closing the light aperture across its narrowest width, has also two double blades of a more or less scissors-like form, which open and close from both sides at the same time, and thereby further reduce the shutter-travel to one-half on both the opening and closing movements, thus making the period of opening and closing cover a shutter-travel of only $\frac{3}{8}$ in. (see Fig. 120), as compared with the diagonal shutter-travel of $1\frac{1}{8}$ in., or three times as great, in the old disc-type shutter.

Another advantage is, that the new kind of revolving shutter does not change position with relation to the light

Figs. 119 and 120.—Gate Apertures, showing Long and Short Shutter-travels respectively

aperture while framing the picture in the gate. Hence a reduction of nearly 50 per cent. in the non-exposure, and a corresponding percentage of gain in duration of exposure of the picture reduces the amount of flicker in an equal proportion, and consequently gives a much brighter, sharper, and more brilliant picture, without any appreciable vibration, as compared with the almost continual flicker observable in many pictures projected by machines having the old form of shutter. Therefore, the elimination of flicker in the picture on the screen depends greatly on the degree of non-exposure as compared with the period of exposure.

Cleaning and Oiling the Machine.—The cinematograph is really a wonderful machine, which requires careful handling if it is to do its work properly. Running as it does at a great speed, some parts of the mechanism must eventually wear out in time, especially so in continuous shows, day after day, without cessation, throughout the year. Therefore, it is of primary importance that the machine should be well cleaned and lubricated, at least once a day. The best oil only should be used. Avoid cheap lubricating oils destitute of body.

One of the best lubricants of all is neat's-foot oil which has been kept for some time, and to which some lead clippings or filings have been added, in order to kill the acid. The clear portion only should be used. This can be separated from the sediment or thicker portion by decantation and filtration through filtering or blotting paper. One drip of this oil will go farther than three times as much of any other lubricant. The next best is pure sperm oil, or a good make of sewing machine oil.

A new machine should have a few hours' trial, in order to "run in" the bearings. It should also be tested for "end shake." Little or no "end shake" shows that the bearings are too tight. A tight bearing may "fire" or "seize" during the first few hours' run, which would be rather awkward if the show were on. End shake has been defined as "the amount of play that can be felt on taking hold of a spindle and pushing and pulling it in the direction of its length." An old machine may run hard through having been neglected. If it is very much clogged, wash out the bearings with paraffin oil and keep on turning the handle until the machine works freely. Then, after wiping up all the dark oil which has exuded during the cleaning process, oil with the best oil only. In some machines a little motor grease may be used advantageously, where a grease box is fitted for the purpose.

The cog-wheels should be lubricated with a little dry black-lead, which is both cleaner and better than oil for these parts. This will reduce noise to a minimum, and also prevent a good deal of " wear and tear."

The film trap also needs special attention daily. It must be perfectly free from any small portions of emulsion which may collect through coming off the film. If necessary, brush and scrape the bow springs, then give them a smear of vaseline, in order that the film may run smoothly, and so prevent, as far as possible, the emulsion from being rubbed off. The springs should have sufficient tension to prevent over-shooting of the film. To test this, place a film in the machine and watch the screen. Turn the handle slowly and notice the general position of the picture, then turn more quickly. If the picture rises slightly on the screen, that shows there is insufficient tension of the springs in the film trap. Bend the springs outwards a bit and tighten up the screws. If the springs have worn thin and are consequently weak, renew them, because when they have been worn thin the sharp edge is apt to cut the margin of the film and so render it useless by causing a break with considerable risk of fire, especially if a portion of the cut film be left in the gate for a few seconds. With the " skate " form of gate spring, however, there is not so much risk of the film being cut. In both cases the steadiness of the picture on the screen will greatly depend upon the tension of the film trap springs.

CHAPTER XIII

What to do if the Film Fires

SHOULD the film fire in the gate of the projector, always remember that the first thing to do is to keep cool. Don't be in a hurry. Know exactly what you should do, then do it, deliberately and promptly, entirely without flurry. This is just where the difference comes in between a well-trained operator and a mere "handle-turner."

First, switch on the auditorium lights with the left hand, and with the right pick up the wet blanket and beat out the flame. Simultaneously, of course, step off the pedal upon which you were standing while operating, and so release the shutters which automatically close the projection and spy holes of the box or chamber. The switching on of the auditorium lights gives the pianist the cue to continue playing, and so keeps the attention of the audience while the operator looks after their interests, although they would and should know nothing about it. Having put out the flame, which should be a mere nothing in a properly-constructed and well-cared-for machine, switch off the arc, and see that the film trap is clear. Then proceed, without losing a second of time, to thread in the remaining film, just as if nothing had happened, and go on with the show exactly as before the accident.

In order to enable the operator to do so efficiently, he should always keep at hand two or three empty spools hanging on nails under the spy hole of the box or chamber. It is then a simple matter to whip out the used spool from the lower magazine and insert an empty one for re-threading.

In addition to the wet blanket ordered by the authorities, it is always advisable to have an extra one, which should be ready to hand in case of an emergency. Keep this on the stand or base-board, and see that it is there ready for use at any and all times. Don't keep it in your kit-bag while operating.

As a matter of fact, the careful operator should have neither a film fire nor even a break at any time. Such a contingency ought not, and should not, occur at all. It will not occur if the operator has properly examined and mended the films, and kept the machine clean, well lubricated, and in good working order—in short, if he has conscientiously done his duty, and cheerfully complied with the regulations, both written and unwritten.

Fire Regulations.—The reader should study the requirements of the Act and Regulations given on later pages; it is convenient here to summarise those regulations relating to fire and its prevention. When a portable operating box is used it should be constructed of No. 16 gauge sheet iron, and be not less than 6 ft. 6 in. × 5 ft. × 4 ft. 6 in. in dimensions, on angle-iron frame, well fitted, and lined with sheet asbestos; and there should be a self-closing door opening outwards, with flange inside, leaving the door flush and smoke-tight. There may not be more than two openings for each lantern in front, having reasonably heavy shutters, working in iron guides, dropping freely and smoke-tight, held up by a light cord and released instantly from outside or inside, either or both, when they close automatically; bushed and insulated openings for the electric cables; and the floor shall, if boarded, be covered with asbestos or other fire-resisting material.

Resistances and transformers are preferably kept outside, or in another room.

The portable box is being rapidly replaced by a permanent chamber, built of brick or concrete, or with a lining of fireproof slabs not less than 3 in. thick, having a self-closing door and shutters fitted in a similar manner to those in the portable box.

The fire appliances required are: Two buckets of water, one bucket of sand, and a wet blanket.

Except the operator and his assistant, no other person is allowed to be in the box with them while operating, unless the local authority requires the presence of a fireman.

Operators must not allow other persons to perform their duties or to work the machine.

Smoking is strictly prohibited at all times in the operating box or chamber; also in the winding-room, when re-winding, mending, and manipulating celluloid films, in any way whatsoever.

Only the spool of film actually being exhibited must be in the operating box. Other spools of film must be kept outside, each one being brought in separately as required, and then placed outside after exhibition.

The regulating resistance must be placed above the level of, and behind, the machine in such a position that should the take-up fail to act, the film could not reach the resistance coils.

The film must not be allowed to collect on the floor under any circumstances whatsoever.

The lantern shall be placed on firm supports constructed of fire-resisting material.

The lamp or jet shall stand on an iron tray having a vertical edge at least 1 in. in depth.

A blank metal slide must always be kept in the slide-carrier, and in the aperture nearest to the operator, in order that the light may be cut off by pushing in, and not by pulling out the carrier slide.

Where possible, the electric arc light shall be adopted as the illuminant.

Circuits on which there is a pressure exceeding 250 volts between the poles or from pole to earth shall not be allowed in connection with the apparatus.

The double-pole switch must be placed in such a position that the operator can cut off the electric current without leaving the machine.

No waste paper or rubbish of any kind must be allowed to accumulate in the operating box or chamber, which must always be kept clean and tidy.

CHAPTER XIV

Cleaning and Repairing Films

FILMS that have seen long or careless service will be found to show scratches and dirt, and, perhaps, portions may be slightly torn, or have broken perforations. Such defects can, as a rule, be easily rectified or repaired.

For cleaning the films and removing scratches a bench or table is required, close to a window and in a room without fire or naked light. The table should be covered with clean white paper, stretched tightly over and secured at the edges with drawing-pins. There will also be needed a few small pieces of soft sponge and a bottle of methylated spirit. The end of the film is laid lengthwise along the bench, celluloid side upwards, and is rubbed gently with a sponge very slightly moistened with methylated spirit. This will clear out fine grit from the scratches, making them far less visible, and will also remove dirty marks. The whole length is done in turn, holding the film up to the light now and then to note progress.

The celluloid side having been treated, next the emulsion side may be examined. This is dealt with in the same manner, but with much greater care, as it is easier to injure. It should only be rubbed very gently, with scarcely any spirit on the sponge, and there is no need to go all over it, but merely on those parts that are dirty or show marks. The film should be handled throughout by the edges alone, to avoid finger imprints. Any traces of grease or oil may be removed separately with a little petrol or benzoline. But be exceptionally careful when using them. The fire risk is considerable.

In many cases, a specially made film-cleaner will pay for itself. A number of patterns are available, the Brockliss-Seaborne (Fig. 121) being excellent. In the illustration, A and B indicate wiping pads which remove

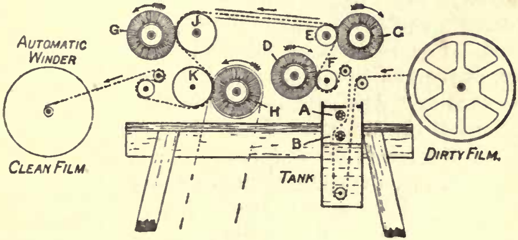


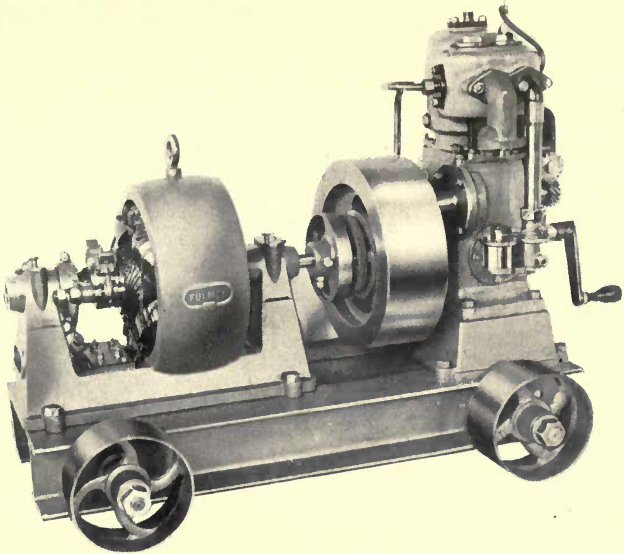
Fig. 121.—Brockliss-Seaborne Film Cleaner

the superfluous moisture (benzoline) from the film before it reaches the brushes C and D, these being soft leather cleaners. Drums E and F are mounted on a rocking lever, and press the film upon the cleaners, while brushes G and H are chamois leather polishers. Drums J and K, mounted on a rocking lever, press the film upon the polishers.

Conspicuous transparent holes or scratches in the pictures themselves may as well be "spotted" out. For this purpose, water-colour is mixed on a palette to the exact tint of the film, adding a slight trace of gum. A convenient film-retouching desk may be extemporised by supporting a piece of plate-glass on a couple of fairly thick books, one at each side. When the film is laid on the glass, the white paper on the bench beneath will reflect light through it and show clearly where work is needed. The colour is applied with a finely-pointed sable brush, using a light dotting or stippling touch, and keeping the brush nearly dry.

Having cleaned and spotted the film, attention may be given to any torn portions or broken perforations. Indeed, films should be examined every time they are re-wound. This is done by allowing the edges, not the faces, of the film to run through the hand in the course of re-winding. Any gaps or tears in the edges and perforations of the film must be cut clean out, even at the sacrifice of a few of the pictures.

In Fig. 122, a typical example, the film is torn partly across at A, while one of the perforations is broken at B. It could not be run through the projector in its present state without a practical certainty of further damage and possibly a dangerous stoppage. To effect a repair, it is necessary to sacrifice one picture at the defective portion and to join the film up again. The places at which the cuts should be made are indicated in Fig. 123, which shows the divided film. It will be seen that one cut is made straight across at the bottom of the damaged picture, while the other is made from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. below the top. The end having the narrow strip A (Fig. 123) is laid gelatine side upwards on the bench, and with a knife and straight-edge the gelatine is scratched through along the line C D—that is to say, at the bottom of the nearest



PORTABLE DIRECT-COUPLED PETROL-DRIVEN DYNAMO

(*For description, see p.* 149)

picture. The strip A should be wetted (by the worker's tongue, or in any other convenient way), when in a few seconds the gelatine can be scraped away, leaving clear celluloid. To cement the two ends, a camel-hair brush and some amyl acetate—a liquid smelling strongly of pears and costing about 3d. per oz.—will be required. The

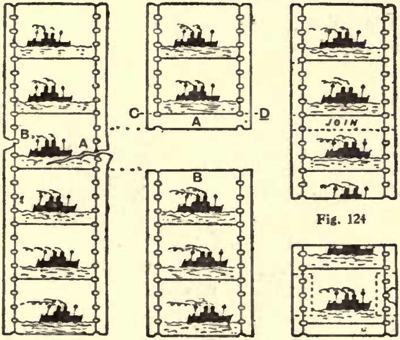


Fig. 124

Fig. 122 Fig. 123 Fig. 125

Fig. 122.—Torn Film with Broken Perforations. Fig. 123.—Method of Cutting Film. Fig. 124.—Repaired Film, showing Join. Fig. 125.—Another Way of Mending Perforations.

end B of the film (Fig. 123) is laid celluloid side upwards on the bench, and a width of about $\frac{1}{4}$ in. is well brushed over with amyl acetate; the liquid is also applied to the narrow strip A on the other portion of the film, which should be placed gelatine side upwards on the bench. The end B of the film is then turned over and laid without delay on the narrow strip A, taking care that the perforations are the proper distance apart and that the junction is true and straight. The effect of the amyl acetate, which is a solvent of celluloid, is to soften the two ends so that they readily adhere. The junction is kept well pressed for about a couple of minutes, and the film is finally left for about ten minutes to harden. The appearance of the mended film is shown by Fig. 124, in which the join is indicated by a dotted line.

Another form of repair—not recommended by the writer—is occasionally used when a perforation only is

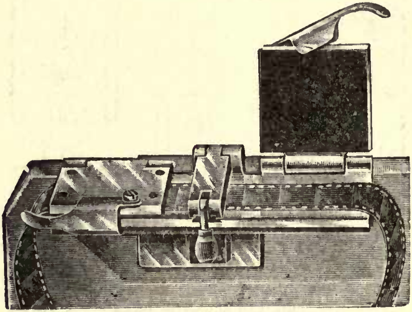


Fig. 126.—Hughes Film Mender

broken, without the film being torn. The edge alone is mended by cementing on at the back of the film a strip of celluloid containing perforations. It is advisable to do this equally at each side, as shown by the dotted lines in Fig. 125, or the film might run unevenly and perhaps jump the sprockets.

It will be seen that the amyl acetate forms a cement by dissolving the surfaces of the pieces of film to which it is applied. Many workers prefer to use a cement already prepared. This may be bought, or it may be made by adding to 1 oz. of the amyl acetate a strip of film about 6 in. long, clean and free from emulsion. Be sure the strip of film is clean, then cut it up, and place in the solvent. It soon dissolves, when it is ready for use, being applied with a camel-hair brush as before.

Another good cement, but one that dries more slowly, is a solution of a 6-in. strip of film in a mixture of ½ oz. of acetone and ½ oz. of amyl acetate. If too thin, add more celluloid; if too thick, add more solvent.

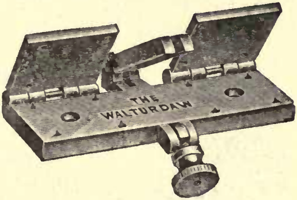


Fig. 127.—The Walturdaw Film Mender

When repairing non-flam film, this not being soluble in amyl acetate, chloroform is the solvent to be employed. This may be used alone, as already explained; but owing to its volatile nature it is better converted into cement by adding fragments of the non-flam film until the proper consistency is obtained, a matter that a few simple experiments will easily decide. Special cements for non-flam films are obtainable.

Special film menders are obtainable in variety. Most of them are of the hinge pattern (see Figs. 126 and 127), the two outer hinges holding the two ends of the film in exact position, the middle portion being closed down upon the completed join.

CHAPTER XV

Film Winders

WHILE a film is running through the projector it is being wound wrong end first on the take-up spool, and obviously before it can be exhibited again it must be entirely re-wound. This takes a good deal of time with any length of film, unless a proper winding appliance is at hand. There is a variety of such appliances obtainable (see Figs. 128 and 131), or one can be made by the operator himself quite cheaply if a couple of suitable toothed wheels are available.

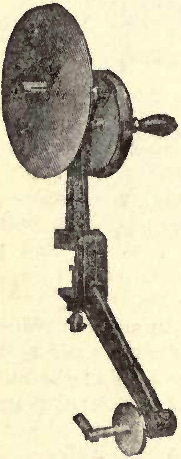
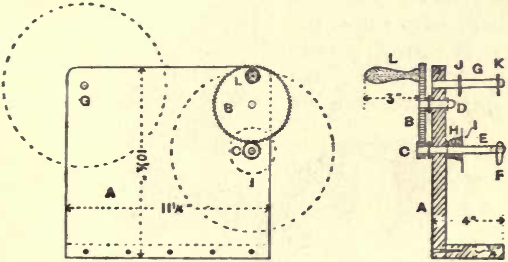


Fig. 128.—Kineto Combined Film and Spool Winder (Double-arm Pattern)

Fig. 129 is a front elevation and Fig. 130 a sectional end elevation, the lettering being the same in each. The support A may consist of two pieces of $\frac{3}{4}$-in. hard wood screwed together at a right angle. The toothed wheels B and C are in the ratio of 4 to 1, or thereabouts; thus one might have sixty-four teeth and the other sixteen teeth. Holes are bored in the support for the $\frac{3}{8}$-in. diameter spindles, and it is better if these holes are bushed with pieces of brass tube. A handle L runs free on a short steel pin screwed in the wheel B. The spindles may be of steel; but it is quite practicable to make them of hard wood if preferred. That for the large wheel, seen at D, is 2 in. long, while that for the small wheel, shown at E, is $4\frac{7}{8}$ in. long, and is slit at the free end to take a drop catch F. The wheels are secured with linch-pins driven through holes bored in the spindles. To keep the spool in position and make it revolve with the spindle, a fairly strong



Figs. 129 and 130.—Details of Home-made Film Winder

spiral spring H and a loose circular metal plate I, $2\frac{1}{2}$ in. in diameter, are provided.

The spindle G for the spool that requires re-winding may be of hard wood; it is 4 in. long, and is fixed tightly in a hole bored in the support. Having adjusted this spool so that it is in alignment with the empty spool on the spindle E, a peg is inserted and glued at J as a stop for one side of the spool, while at the other side a removable peg K is provided. These should be just far enough apart to allow absolutely free movement of the spool. Instead of the pegs, it is an improvement to fit the spindle

G with a drop catch, spiral spring, and disc similar to those on E; but the spring must be weak, as there should be no resistance to the unwinding of the film.

To use the appliance, a full spool as run off from the projector is placed on the spindle G, and the peg K is inserted or the drop catch secured. An empty spool is adjusted on the spindle E. The large dotted circles in Fig. 129 show the positions of the two spools. The end of the film is carried several times round on the empty spool, then on

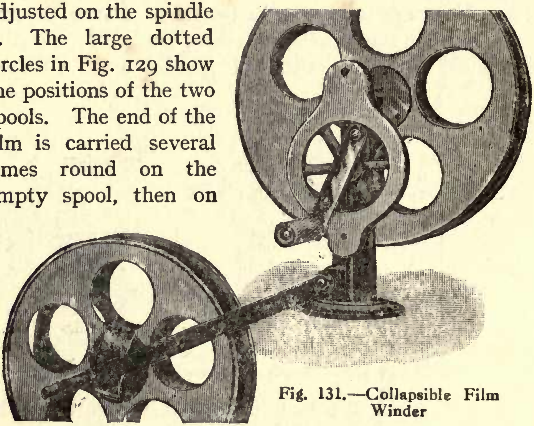


Fig. 131.—Collapsible Film Winder

turning the handle the film will be rapidly re-wound, since the spool on E will revolve four times as fast as the handle is turned. Care must be taken that the film runs freely, otherwise a breakage might occur; also, it is necessary to stop winding just before coming to the end, in order to detach the film from the spring clip on the original spool. The winder is adapted for spools up to 9 in. in diameter; but by increasing the size of the support larger spools could be taken.

CHAPTER XVI

Natural Colour Cinematograph Pictures

Of the many attempts to produce cinematograph pictures in natural colours on a scientific basis, as distinct from the method of painting or dyeing an ordinary film, the greatest amount of attention so far has been attracted by a system invented by G. Albert Smith, and commercially developed by Charles Urban under the name of "Kinemacolor." In this system (to quote from "Cassell's Cyclopædia of Photography," edited by the editor of this present book), only two colour filters are used in taking the negatives and only two in projecting the positives. The camera resembles the ordinary cinematographic camera except that it runs at twice the speed, taking thirty-two images per second instead of sixteen, and it is fitted with a rotating colour filter in addition to the ordinary shutter. This filter is an aluminium skeleton wheel (Fig. 133) having four segments, two open ones, G and H; one filled in with red-dyed gelatine, E F; and the fourth containing green-dyed gelatine, A B. The camera is so geared that exposures are made alternately through the red gelatine and the green gelatine. Panchromatic film is used, and the negative is printed from in the ordinary way, and it will be understood that there is no colour in the film itself.

The projecting apparatus is shown in Fig. 132. It works at double ordinary speed, projecting thirty-two images per second, sixteen being projected through the green segment of the colour filter A, and the other sixteen through the red segment. The arrow H indicates the direction of the light rays from the illuminant; C is a light guard, preventing stray light from passing to the screen; D the driving pulley, F the film, E E safety spool boxes, G governor balls and B safety shutter.

A special feature in the formation of the colour

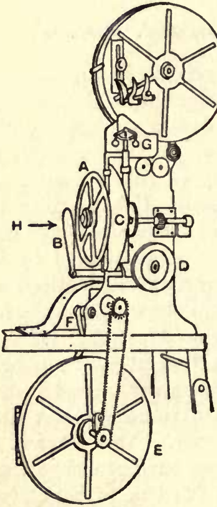


Fig. 132.—Kinemacolor Projector

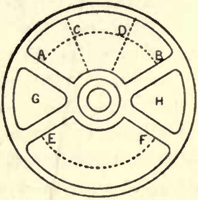


Fig. 133.—Kinemacolor Filter

filter must now be referred to. Supplementary to the green filter A B (see Fig. 133) an overlapping segment of green is filled from C to D with the object of obtaining balance of colour, since red is more vivid to the eye than green. The size of this supplementary segment C D is a matter of importance. If it is not large enough, the yellows will have a greenish hue; if it is too wide, the green will be too dense and the red will be in excess, giving to the yellow an orange hue. If the red and green filters have been rightly balanced, the revolving disc will transmit to the screen a neutral white "colour."

When taking the negative photographs, the speed of film through the camera must be maintained at 2 ft. per second, otherwise the object, when projected, will appear to move at an unnatural pace. Assuming a uniform rate of projection, increased speed of taking will cause an effect of abnormally slow motion in the projected pictures; while if the subject is taken too slowly, the projected images will show everything moving too fast.

In the projecting machine, at the moment when the red filter is opposite the lens, a monotone image taken through the green filter will be in the gate and be projected, and vice versa. The images following in this order at the high speed of thirty-two images per second, the combined effect upon the screen will be a picture reflecting not only red and green, but also their complementary or accidental colours intermixed with many other hues resultant from the blending of the red and green proper.

An ideal process of natural colour cinematography would be that in which the three primary colours of the solar spectrum were embraced, taking the negative images through suitable colour filters and projecting positive images therefrom through yellow, blue and red filters; but the chemical, optical, and mechanical difficulties of doing this are extremely great.

CHAPTER XVII

Making Trick Films

In the production of trick films resort is had chiefly to double printing, better known as combination printing. This is practised when transformation scenes have to take place, such, for instance, as a summer landscape suddenly becoming a winter scene. Also in cases where spirits from the unseen world are made to appear, or the visions and dreams of a sleeper are made visible as an aerial spectre. All such effects are produced by composite printing. It will be noticed that in most cinematograph pictures embracing such effects the composition contains a black background at that point where the apparition first makes its appearance, and herein lies the secret, or rather the possibility, of the introduction of the ghostly figures. It will also be noticed that the figures made to appear are generally clad in white attire.

Ghost Scenes. — The trick is worked as follows: Supposing the scene is one in which a ghost has to make its appearance. Surrounding or at the side of the black background the ordinary furniture of a room may be arranged, the occupants taking their places at any position, except immediately in front of the black background referred to, which place is essentially kept clear for the apparition. The stage arrangement having been completed in this manner the scene is enacted before a cinematograph camera, the actors assuming to see the ghost and regulating their movements accordingly. The camera operator will thus have secured a negative showing a scene of people acting as though they saw a ghost. Without moving the camera from its original position a second negative film is taken; this time with all the furniture removed from the stage, and the back entirely covered with a black cloth. The marks on the stage floor should be used as a guide to the one acting the part of the ghost, so that he may walk in, and confine his movements to the limits indicated by the marks. The ghost, being a figure clad in white, first stands at the position where he is to become visible, and then moves forward on the stage, acting as though making motions and signs to the company assumed to be in the room. The actions must, of course, be so arranged as to fit in with the acting of the people taking part in the scene previously photographed, and the length of time occupied by the ghost is also regulated to agree with the previous scene.

The second negative being secured completes a pair of films from which it is possible to make a so-called composite-positive print. For this purpose a printing machine is used. This consists of mechanism somewhat similar to that used for the projection of the pictures on the lantern screen, only instead of the film being intermittently brought to a standstill it is carried through the apparatus with a continuous motion, whilst a small slot-like opening, opposite an electric lamp, causes it to become exposed. Thus the developed and dried negative film is turned gelatine side towards, and in contact with, the unexposed and sensitive side of a second film on which the positive is to be made. This contact printing is very similar to that of ordinary negatives on bromide paper. The two films are passed simultaneously, and in contact with each other, through the rotary printing machine. The positive film having passed through with the first negative obtained in contact therewith, it is passed through a second time with the second negative in contact.

At this stage it is important to make provision for registration of perforations, and as there is nothing as yet visible on the positive film it is necessary to make some indication to show where the first printing from the first negative commences. Registration is all important to success. To make the ghost appear apparently out of thin air the second printing is regulated with this object in view. Thus, as the printing of the ghost commences, the machine is operated rather fast at first, and then slowed down to the normal speed. The result is that the image of the ghost is but faintly impressed at the commencement, and gradually becomes more impressed with the increase of exposure. The reverse will take place at the end of the scene or film if the speed is varied. Thus, in the projected picture on the lantern screen, the ghost will gradually make its appearance, and as gradually fade away. When the positive film has received its duplex impressions from the two negatives in the manner described, it is developed in the usual way.

"Stop Camera" Tricks.—The sudden appearance and disappearance of figures in a scene is often produced by the "stop camera" trick. A scene is cinematographed, and the camera may be stopped working for a moment to allow the introduction of additional figures into the scene, the figures having taken up their positions whilst the camera has remained inoperative. The camera is again worked, and the scene thus continued without a break in the series of pictures, but with the sudden addition of introduced figures.

Illusions as to Size, Distance, Motion, etc.—The gradual enlarging of objects, and the diminution of the same, can be produced either by running the camera forwards and backwards during the operation of taking, or the objects can be moved towards or away from the camera. The effect of a balloon ascent can be produced by keeping the balloon stationary within the field of view, whilst a background roller blind, on which is depicted clouds, can be rolled from a top to a bottom roller. This will create the impression that the balloon is actually rising, whilst a reverse motion of the blind will suggest that it is descending.

A Man Walking through a Wall.—This is one of the double-exposure type of trick films. Thus a picture is first taken minus the man. The film is then wound back into the top magazine of the camera. (Mechanism for this purpose is fitted to all modern trick cameras for cinematograph work.) The amount of film expended on the first exposure is carefully noted, which is determined by reference to the speed indicator fitted to the side of the camera ; this is done before winding back into the top magazine. Against a plain background the man now walks through an allotted space, regulating his movements with due respect to the assumed presence of the wall. The film is run through the camera a second time, this time taking the man only. The film is thus doubly impressed. On development a negative will have been secured that will give by a single print taken by contact a picture of a man walking through a visible wall.

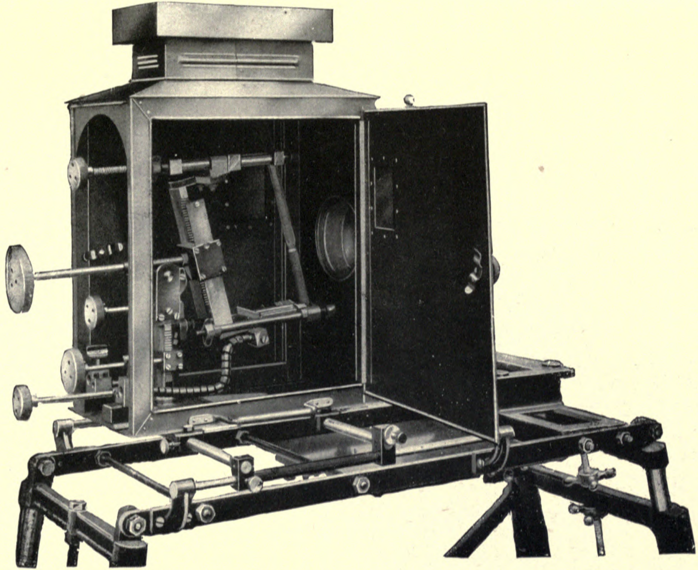
Appearing and Disappearing Visions in a Seemingly Well-lighted Room.—This, again, depends for its results on the double-printing or double-exposure method. During the period of exposure allotted for the spectral appearances the space to be so occupied is vignetted out with opaque media, so that the first exposure in the camera results in impressions of the interior of the room with its furniture, etc., but with an unexposed or blank space corresponding to that to be occupied by the spectral images, timing and expenditure of film length being carefully regulated to suit the time the spectral effects are to be evident. The first exposure made, the film is wound back to the top magazine of the camera. The vision scene, or spectre, is now to be impressed on the film. An opaque mask is placed in the exposure aperture suitable in shape for completely covering the already exposed parts of the film, but with an opening corresponding to the part first vignetted out. Through this aperture the spectral image is to make its impression on the film as it is for the second time run through the camera. The subject forming the spectre must be situated a considerable distance from the camera; so that when focused sharply and reduced to a plane it is of the right magnitude to give reduced figures, as compared to the figures or figure in the first scene. Melting away effects, otherwise called dissolving effects, may be brought about in various ways. Some manufacturers produce them by gradually stopping down the lens during exposure, which, of course, produces diminishing exposure; consequently final invisibility obtains. The aperture of the iris diaphragm is gradually opened out for reappearance. Other makers prefer to secure the effect by control of the light during the printing operations.

Hand-bolted Prisoner Releasing Himself and Walking Through the Bars of His Apartment.—An important accessory is needed here in the form of inflatable rubber arms and hands, to which is attached a rubber tube and bulb. The real arms and hands of the prisoner are concealed beneath his dress, so that he is free to actuate the artificial limbs at the required moments and in the required manner. When the chains are put on, the rubber hands are inflated by squeezing this secreted bulb, then at the right time the bulb is allowed to go free, when the air immediately rushes out of the hands, allowing the latter to become limp, elongated, or putty-like. This allows the chains to fall off. When the prisoner presses the bulb the hands again assume normal proportions. Walking through the bars, or rather assuming to do so, is produced by the double-exposure dodge. The prisoner is absent during the first exposure when the bars are in place, and present only when the bars have been removed for the second picture or exposure.

A Horse and Cart Going up a House-side.—The house is taken on the film first, then the film is wound back into the top magazine of the camera. The camera is now turned on its side, and a picture of the horse and cart, travelling over a prearranged space, is taken over the same film by exposure a second time. This gives a negative showing the horse and cart going at right angles to the horizon, corresponding at the same time with the perpendicular position of the house or wall. This and many other tricks of a similar nature may be done, either by the double-exposure of the negative, or two separate negatives may be taken and double printing resorted to when making the positive film. The former method is generally that adopted, owing to the greater simplicity of making positives afterwards, a large number often being required. It is also better because the same perforations are in action in both subjects forming the duplex negative.

Seraphim in the "Life of Christ" are made to appear and disappear by adopting one of the methods above described.

The Napoleon Scene.—The bust on the mantelpiece is gradually vignetted out of the composition during the progress of the film through the camera. A real man impersonating Napoleon is printed in afterwards from a separately obtained negative. The distance of the Napoleon together with his movements towards the camera are prearranged with regard to size and positions to be occupied by him. The space where the battle appears to take place is blocked out in the film first exposed, and in the second exposure of the same film the space to be occupied by the view of the room interior with its dozing veteran is blocked out, so that the spectral space only is subject to exposure. The group of figures constituting the battle scene, including the veteran, is located at an increased distance from the camera, so that its magnitude is suitable for exactly filling the space reserved for the phantom scene. The lens is focused for this distance, and the film run through the



LANTERN OR LAMP-HOUSE SHOWING ARC-LAMP, ADJUSTABLE STAND, ETC.
(*Gaumont type*)

camera a second time. From this it will be understood how it is possible for the veteran to be seen dozing in his room, and at the same moment taking part in the battle scene; for he is not required to be in two places at the same time to be duly photographed in both.

A True Presentment.—The camera is stopped for the purpose of substituting a mirror for a picture, while the images seen in the mirror get there by reflection, the actors being at an angle with the mirror and at such a distance that their magnitude is apparently reduced. Double exposure is here resorted to, and the process is similar to that of the veteran picture already described.

It is worthy of note that these reduced living images are not in reality reduced, but appear to be so, owing to their greater distance from the camera, and especially because all cinematograph pictures are reduced to one plane; that is, they are flat images on a flat surface (the lantern sheet). Hence they do not present a double perspective for consideration, and herein lies the power to deceive the eyes of the observer, who is unwittingly robbed of that sense of sight known technically as binocular perception (vision of two eyes in nature).

CHAPTER XVIII

Cinematograph Exhibitions at Home

Drawing-room cinematograph displays are becoming increasingly popular, and numerous projectors suitable for home exhibition are obtainable at prices that are modest compared with those of the heavier and more elaborate machines intended for use in halls or theatres. Thus it is possible to procure a well-made and workmanlike apparatus taking the standard Edison gauge films and having both lantern and cinematograph lenses, so that slides may be shown as well as films, from about £5 15s. Less expensive still are the cinematograph attachments for use with an ordinary magic-lantern. These may be procured in various patterns from £3 5s. It is not recommended to go below the above prices. There are, indeed, many cheaper models, but, generally speaking, they are only toys, and are not adapted for the serious exhibition of any length of film. The larger cinematograph supply firms often offer good second-hand projectors at reduced prices, or they may sometimes be got by studying advertisements of articles for sale or exchange. In the latter case, the deposit-approval system should be insisted on. As the vast majority of films are made to the Edison standard gauge and perforation, it is the best policy to secure a projector that will take it.

Many cinematograph dealers supply projectors and films on the hire-purchase system, as well as for hire by the evening or week. Terms vary, and must be inquired individually. Films may be purchased or hired at much lower rates if a few months old, a newly-issued film always commanding an enhanced price. Beyond a few hints as to the class of entertainment desired, it is usually best to leave the choice of films to the supply firm. In estimating the length required it is useful to remember that about 1 ft. of Edison standard film, containing sixteen pictures, is run through the machine per second—a rate, therefore, of 3,600 ft. per hour for an unbroken display.

It is certainly wiser to use non-inflammable film for home exhibitions, if possible, since it does not call for so many precautions as the ordinary celluloid kind. Assuming celluloid film to be used, home cinematograph displays should be given in the largest room available, so that a clear space may be left round the lantern. If this can be placed in a doorway just outside the room, so much the better, as in case of any mishap the audience may instantly be cut off by closing the door. This cannot be done unless there is more than one door, as an unobstructed exit should always be available. There should be no curtains or drapery near the lantern. On no account should the operator smoke, nor should smoking be allowed anywhere near the machine. There should be no naked light or stove in proximity to the film, and the supplies must not be close enough to the lantern to get hot.

The film must not be suffered to stand still while showing, or the portion in the gate will quickly become hot enough to ignite. If any stoppage occurs, either a safety shutter must promptly be brought into action, or, if using an ordinary lantern, an opaque slide, placed in readiness in the carrier, may be pushed forward to cut off the light. It is safer if a flat-sided glass tank filled with water or with an alum solution is placed between the condenser and the film to absorb some of the heat. It will be as well to form a barrier of some kind, even if consisting only of a few chairs, to prevent anyone, especially children, approaching too closely with inquisitive intentions. The films should not be left lying about before or after the exhibition, but should be kept well out of harm's way. Loose film should be enclosed in a metal box. As precautionary measures, two buckets of water, a bucket of dry sand, and a damp blanket should be kept close at hand. A reminder may here be expedient that a home display with celluloid films must be strictly private. The public must not be admitted, whether for payment or without, otherwise the provisions of the Cinematograph Act (1909) will apply.

The arc light is not usually available for home displays, nor is it perhaps the safest illuminant for the purpose on account of the heat produced and the extra care required. As the screen will not be very large or very distant, so powerful a light is really unnecessary. Except to one well accustomed to handle it, limelight also introduces uncalled-for complications. Incandescent gas and acetylene are very suitable for a small screen not over about 3 ft. in diameter, and for quite a small picture it is even possible to use a good three- or four-wick paraffin lamp. As the film picture is much smaller than a lantern slide, it is easier to get an even and concentrated illumination. The cinematograph objective, being of shorter focus than a lantern objective, compensates for the small size of the original image by giving a greater ratio of enlargement at the same distance from the sheet.

The screen should be a pure, opaque white; if it lets any light through, so much is obviously lost. A linen or calico sheet stretched on a wooden frame and given several coats of good, stiff whitewash is difficult to beat; or, for a small screen, smooth, thick white Bristol board is excellent. It is an improvement if the screen has a black margin all round, almost up to the picture. The apparent size of the screen may be increased and a more effective display obtained by draping plush curtains or other suitable material at the top and sides, to simulate a stage, and disposing a few plants or palms on the ground in front. With a weak illuminant, incapable of giving a large image, the lantern will have to be brought very close to the screen, and will be in the way of the spectators. In such a case, it is best to use a tracing paper or ground-glass screen set in a curtained frame, and to work from behind it. To find the approximate size of picture at a given distance, divide the distance of the cinematograph from the screen in feet by the focus of the lens in inches. The quotient gives the diameter of picture in feet. Thus, for example, at 6 ft. from the screen, a 2-in. focus cinematograph objective gives a 3-ft. picture.

A musical accompaniment to the pictures is now generally expected. A little thought devoted to this to secure appropriateness will greatly add to the success of the entertainment, especially if the pianist can be coached to introduce a few "effects."

The cinematograph should be stood on a firm, rigid support. Anything hollow, such as a box, will induce vibration and cause unsteadiness of the pictures. The film should be inserted emulsion side to the condenser, with the pictures upside down. If, however, the machine is worked behind a transparent screen, the celluloid side should face the condenser. It should be noted that the spool has the commencement of the film outside, for sometimes it is supplied as last wound off, when the end will, of course, be uppermost, and re-winding on another spool is necessary. This must always be done between any two exhibitions. The beginning of the film will have the sky or people's heads outwards.

The threading up varies with different makes of projectors; but with practically all it should be seen that a short loop of film is left just above the gate. In addition to this, a Maltese cross machine needs a loop between the intermittent sprocket wheel and the take-up sprocket, while a pin or claw type of projector requires a loop below the gate. If these rules are not observed a breakage is probable. Care should be taken that the sprockets engage the perforations properly. Needless to say, it is necessary to be gentle with hired films, as it will not do to return them scratched or damaged. If in doubt as to the working of the machine it will be as well to buy a few yards of discarded film and to practise running this through until the method is grasped. Many dealers and toyshops sell old films that have had their day, at about a penny per yard.

The amateur cannot at first expect to insert and change the films with anything like the speed of an expert, and to avoid awkward waits it is decidedly advisable to have a machine furnished also with an ordinary lantern lens so that a few stationary slides or announcements may be shown. If well chosen, these will have a good effect and will help to lengthen an otherwise too-short programme. The machine, in such a case, either slides sidewise, or swings round so that the lantern lens is presented in front of the condenser instead of the film mechanism and objective; or the lantern itself slides on parallel rails or grooves while the cinematograph casting carries the two objectives side by side and is immovable. The lantern lens should be separately focused with a slide in position before starting with the cinematograph. To the novice a rehearsal beforehand is certainly expedient.

It is unwise to have the room in total darkness. A gas-jet turned almost down may be useful, or, better still, one or two metal lanterns glazed with red glass; dark-room lamps will do. The seats should not be placed too close together or too near the screen. A final hint that may be given is to avoid allowing a white light to show on the screen during an interval, as this dazzles the eyes and has a slipshod appearance. The light should be cut off directly the end of the film is reached or a lantern slide brought into view. If requested, the dealer will supply the film joined up on the spools between the different items with black spacing, so that there is no need for a stoppage. It is then only necessary to exchange the exhausted spool for another if more than one is used.

Projecting Picture Postcards, etc.—A pleasing break in the home cinematograph entertainment may take the form of picture postcards, other small pictures, or even solid articles in relief such as watches, etc., being projected in all their natural colours on the screen, the instrument used for the purpose being an aphengescope. Figs. 134 to 136 show details of a lantern for projecting postcards, Fig. 134 being a sectional plan, and Fig. 135 back elevation, with the revolving door removed. The

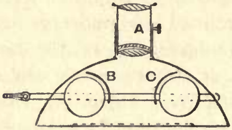


Fig. 134.—Horizontal Section through Picture Postcard Projector.

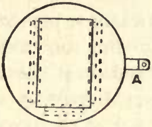


Fig. 136.—Revolving Door of Picture Postcard Projector.

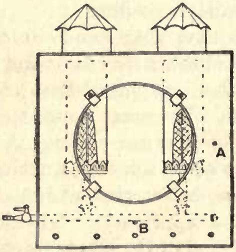


Fig. 135.—Back Elevation of Picture Postcard Projector.

body, of tinplate or sheet-iron, is 1 ft. square, the curved front being of such a depth that the centre A of the lens (Fig. 134) is at a distance from the postcard equal to its focal length. A 6-in. focus lens A will be suitable; it should be of large aperture, and capable of covering the full postcard size. A single lens is unsuitable; one of the portrait or lantern type is required. An ordinary lantern lens, costing from 8s. 6d., can be used, but as this is only made to cover a slide 3¼ in. square it will not project the whole of the postcard. If, however, the cards are selected with this restriction in view, that is no great objection. To show the whole of the postcard the lens should cover at least full postcard size (5½ in. by 3½ in.). A lantern lens is usually of about 6-in. focus, and should therefore be so fixed that the middle of the brass mount is 6 in. distant from the postcard. The rack adjustment will then allow sufficient play for accurate focusing on the screen. At the back of the lantern is a circular opening 7 in. in diameter, the edge being recessed ⅜ in. all round to receive the revolving door. Four bent strips are fixed to keep this in place, two being soldered and two fastened with small nuts, so that they will turn. Holes are made at A and B (Fig. 135) to engage the milled-head screw on the door, and keep the latter in the correct position for horizontal or vertical pictures. The revolving door (Fig. 136) is 7½ in. in diameter, with a rectangular opening 5¼ in. by 3¼ in. On three sides of this are soldered bent guides to take the sheath which holds the postcards, as indicated by the dotted lines. At one side is soldered a strip of brass A, bent so as to clear the strips round the circular opening, and made to take a milled head screw. The sheath measures 5⅝ in. by 3⅝ in. in its rectangular part, with an additional ¾ in. at the curved end; ¼ in. extra is allowed on three sides for turning over, which should be done so that the sheath is 1–16 in. deep and has a turned-over portion 3–16 in. wide. Two incandescent gas burners are fitted as shown, with cowled chimneys over them and a tap at the side. The burners should be placed so as to give the best possible light on the postcard, while not obstructing the path of the reflected rays to the lens. To screen off direct light from the lens, reflectors may be fixed at B and C (Fig. 134). Ventilation holes should be made at the back of the lantern, and covered inside with bent strips of tinplate. The outside may be japanned, and the inside is painted white.

CHAPTER XIX

Acts and Regulations

THE professional operator will need to be familiar with the Cinematograph Act of 1909 and with the regulations issued, under that Act, by the Secretary of State, and also —in the London area—with the regulations adopted by the London County Council. These are, therefore, given word for word in this chapter.

CINEMATOGRAPH ACT, 1909

[9 EDW. 7. CH. 30]

1. An exhibition of pictures or other optical effects by means of a cinematograph, or other similar apparatus, for the purposes of which inflammable films are used, shall not be given unless the regulations made by the Secretary of State for securing safety are complied with, or, save as otherwise expressly provided by this Act, elsewhere than in premises licensed for the purpose in accordance with the provisions of this Act.

2.—(1) A county council may grant licences to such persons as they think fit to use the premises specified in the licence for the purposes aforesaid on such terms and conditions and under such restrictions as, subject to regulations of the Secretary of State, the council may by the respective licences determine.

(2) A licence shall be in force for one year or for such shorter period as the council on the grant of the licence may determine, unless the licence has been previously revoked as hereinafter provided.

(3) A county council may transfer any licence granted by them to such other person as they think fit.

(4) An applicant for a licence or transfer of a licence shall give not less than seven days' notice in writing to the county council and to the chief officer of police of the police area in which the premises are situated of his intention to apply for a licence or transfer:

Provided that it shall not be necessary to give any notice where the application is for the renewal of an existing licence held by the applicant for the same premises.

(5) There shall be paid in respect of the grant, renewal, or transfer of a licence such fees as the county council may fix, not exceeding in the case of a grant or renewal for one year one pound, or in the case of a grant or renewal for any less period five shillings for every month for which it is granted or renewed, so however that the aggregate of the fees payable in any year shall not exceed one pound, or, in the case of transfer, five shillings.

(6) For the purposes of this Act, the expressions "police area" and "chief officer of police," as respects the city of London, mean the city and the Commissioner of City Police, and elsewhere have the same meanings as in the Police Act, 1890.

3. If the owner of a cinematograph or other apparatus uses the apparatus, or allows it to be used, or if the occupier of any premises allows those premises to be used, in contravention of the provisions of this Act or the regulations made thereunder, or of the conditions or restrictions upon or subject to which any licence relating to the premises has been granted under this Act, he shall be liable, on summary conviction, to a fine not exceeding twenty pounds, and in the case of a continuing offence to a further penalty of five pounds for each day during with the offence continues, and the licence (if any) shall be liable to be revoked by the county council.

4. A constable or any officer appointed for the purpose by a county council may at all reasonable times enter any premises, whether licensed or not, in which he has reason to believe that such an exhibition as aforesaid is being or is about to be given, with a view to seeing whether the provisions of this Act, or any regulations made thereunder, and the conditions of any licence granted under this Act, have been complied with, and if any person prevents or obstructs the entry of a constable or any officer appointed as aforesaid, he shall be liable, on summary conviction, to a penalty not exceeding twenty pounds.

5. Without prejudice to any other powers of delegation, whether to committees of the council or to district councils, a county council may, with or without any restrictions or conditions as they may think fit, delegate to justices sitting in petty sessions any of the powers conferred on the council by this Act.

6. The provisions of this Act shall apply in the case of a county borough as if the borough council were a county council, and the expenses of the borough council shall be defrayed out of the borough fund or borough rate.

7.—(1) Where the premises are premises licensed by the Lord Chamberlain the powers of the county council under this Act shall, as respects those premises, be exerciseable by the Lord Chamberlain instead of by the county council.

(2) Where the premises in which it is proposed to give such an exhibition as aforesaid are premises used occasionally and exceptionally only, and not on more than six days in any one calendar year, for the purposes of such an exhibition, it shall not be necessary to obtain a licence for those premises under this Act if the occupier thereof has given to the county council and to the chief officer of police of the police area, not less than seven days before the exhibition, notice in writing of his intention so to use the premises, and complies with the regulations made by the Secretary of State under this Act, and, subject

to such regulations, with any conditions imposed by the county council, and notified to the occupier in writing.

(3) Where it is proposed to give any such exhibition as aforesaid in any building or structure of a movable character, it shall not be necessary to obtain a licence under this Act from the council of the county in which the exhibition is to be given if the owner of the building or structure—

(*a*) has been granted a licence in respect of that building or structure by the council of the county in which he ordinarily resides, or by any authority to whom that council may have delegated the powers conferred on them by this Act; and

(*b*) has given to the council of the county and to the chief officer of police of the police area in which it is proposed to give the exhibition, not less than two days before the exhibition, notice in writing of his intention to give the exhibition; and

(*c*) complies with the regulations made by the Secretary of State under this Act, and, subject to such regulations, with any conditions imposed by the county council, and notified in writing to the owner.

(4) This Act shall not apply to an exhibition given in a private dwelling-house to which the public are not admitted, whether on payment or otherwise.

8. This Act shall extend to Scotland subject to the following modifications:—

(1) For references to the Secretary of State there shall be substituted references to the Secretary for Scotland:

(2) For the reference to the Police Act, 1890, there shall be substituted a reference to the Police (Scotland) Act, 1890:

(3) The expression "county borough" means a royal, parliamentary, or police burgh; and the expression "borough council" means the magistrates of the burgh; and the expression "borough fund or borough rate" means any rate within the burgh leviable by the town council equally on owners and occupiers:

(4) The provision relating to the delegation of powers shall not apply.

9. This Act shall extend to Ireland subject to the following modifications:—

(1) For references to the Secretary of State there shall be substituted references to the Lord Lieutenant:

(2) The provision of this Act relating to the delegation of powers shall not apply:

(3) Any of the powers conferred on the county council by this Act may be exercised by any officer of the council authorised in writing by the council in that behalf for such period and subject to such restrictions as the council think fit:

(4) In any urban district other than a county borough, and in any town, the provisions of this Act shall apply as if the council of the district and the commissioners of the town, as the case may be, were a county council:

(5) The expenses incurred in the execution of this Act shall—

(*a*) in the case of the council of any county other than a county borough, be defrayed out of the poor rate and raised over so much of the county as is not included in any urban district or town;

(*b*) in the case of the council of any county borough or other urban district, be defrayed out of any rate or fund applicable to the purposes of the Public Health (Ireland) Acts, 1878 to 1907, as if incurred for those purposes;

(*c*) in the case of the commissioners of any town, be defrayed out of the rate leviable under section sixty of the Towns Improvement (Ireland) Act, 1854: Provided that the limits imposed upon that rate by that section may be exceeded for the purpose of raising the expenses incurred under this Act by not more than one penny in the pound:

(6) The expression "town" means any town as defined by the Local Government (Ireland) Act, 1898, not being an urban district:

(7) The expressions "police area" and "chief officer of police" mean, as respects the police district of Dublin Metropolis, that district and the chief commissioner of the police for that district, and elsewhere a police district and the county inspector of the Royal Irish Constabulary.

10. This Act may be cited as the Cinematograph Act, 1909, and shall come into operation on the first day of January nineteen hundred and ten.

STATUTORY RULES AND ORDERS, 1910 (No. 189)

REGULATIONS, DATED FEBRUARY 18, 1910, MADE BY THE SECRETARY OF STATE UNDER THE CINEMATOGRAPH ACT, 1909 (9 EDW. 7, C. 30).

In pursuance of the power vested in me by the Cinematograph Act, 1909 (9 Edw. 7, c. 30), I hereby make the following regulations:—

GENERAL.

1. In these regulations the word "building" shall be deemed to include any booth, tent, or similar structure.

2. No building shall be used for cinematograph or other similar exhibitions to which the Act applies, unless it be provided with an adequate number of clearly indicated exits so placed and maintained as readily to afford the audience ample means of safe egress.

The seating in the building shall be so arranged as not to interfere with free access to the exits; and the gangways and the staircases, and the passages leading to the exits shall, during the presence of the public in the building, be kept clear of obstructions.

3. The cinematograph operator and all persons responsible for or employed in or in connection with the exhibition shall take all due precautions for the prevention of accidents, and shall abstain from any act whatever which tends to cause fire and is not reasonably necessary for the purpose of the exhibition.

FIRE APPLIANCES.

4. Fire appliances adequate for the protection of the building shall be provided, and shall include at least the following, namely, a damp blanket, two buckets of water, and a bucket of dry sand. In a building

used habitually for the purpose of cinematograph or other similar exhibitions they shall also include a sufficient number of hand grenades or other portable fire-extinguishers.

The fire appliances shall be so disposed that there shall be sufficient means of dealing with fire readily available for use within the enclosure. Before the commencement of each performance the cinematograph operator shall satisfy himself that the fire appliances intended for use within the enclosure are in working order, and during the performance such appliances shall be in the charge of some person specially nominated for that purpose who shall see that they are kept constantly available for use.

ENCLOSURES.

Regulations applying in all cases and to all classes of buildings.

5.—(1) (*a.*) The cinematograph apparatus shall be placed in an enclosure of substantial construction made of or lined internally with fire-resisting material and of sufficient dimensions to allow the operator to work freely.

(*b.*) The entrance to the enclosure shall be suitably placed and shall be fitted with a self-closing close-fitting door constructed of fire-resisting material.

(*c.*) The openings through which the necessary pipes and cables pass into the enclosure shall be efficiently bushed.

(*d.*) The openings in the front face of the enclosure shall not be larger than is necessary for effective projection, and shall not exceed two for each lantern. Each such opening shall be fitted with a screen of fire-resisting material, which can be released both inside and outside the enclosure so that it automatically closes with a close-fitting joint.

(*e.*) The door of the enclosure and all openings, bushes and joints shall be so constructed and maintained as to prevent, so far as possible, the escape of any smoke into the auditorium. If means of ventilation are provided, they shall not be allowed to communicate direct with the auditorium.

(*f.*) If the enclosure is inside the auditorium, either a suitable barrier shall be placed round the enclosure at a distance of not less than two feet from it, or other effectual means shall be taken to prevent the public from coming into contact with the enclosure.

(*g.*) No unauthorised person shall go into the enclosure or be allowed to be within the barrier.

(*h.*) No smoking shall at any time be permitted within the barrier or enclosure.

(*i.*) No inflammable article shall unnecessarily be taken into or allowed to remain in the enclosure.

Regulations applying only to specified classes of buildings.

(2) In the case of buildings used habitually for cinematograph or other similar exhibitions, the enclosure shall be placed outside the auditorium; and in the case of permanent buildings used habitually as aforesaid the enclosure shall also be permanent.

Provided, with regard to the foregoing requirements, that, if the licensing authority is of opinion that compliance with either or both of them is impracticable or in the circumstances unnecessary for securing safety and shall have stated such opinion by express words in the licence, the requirement or requirements so specified shall not apply.

LANTERNS, PROJECTORS AND FILMS.

6. Lanterns shall be placed on firm supports constructed of fire-resisting material, and shall be provided with a metal shutter which can be readily inserted between the source of light and the film-gate.

The film-gate shall be of massive construction and shall be provided with ample heat-radiating surface. The passage for the film shall be sufficiently narrow to prevent flame travelling upwards or downwards from the light-opening.

7. Cinematograph projectors shall be fitted with two metal film-boxes of substantial construction, and not more than fourteen inches in diameter, inside measurement, and to and from these the films shall be made to travel. The film-boxes shall be made to close in such a manner, and shall be fitted with a film-slot so constructed, as to prevent the passage of flame to the interior of the box.

8. Spools shall be chain or gear driven and films shall be wound upon spools so that the wound film shall not at any time reach or project beyond the edges of the flanges of the spool.

9. During the exhibition all films when not in use shall be kept in closed metal boxes.

LIGHTING.

10. Where the general lighting of the auditorium and exits can be controlled from within the enclosure, there shall also be separate and independent means of control outside and away from the enclosure.

11. No illuminant other than electric light or limelight shall be used within the lantern.

Electric Light.

12.—(*a.*) Within the enclosure the insulating material of all electric cables, including "leads" to lamps, shall be covered with fire-resisting material.

(*b.*) There shall be no unnecessary slack electric cable within the enclosure. The "leads" to the cinematograph lamp shall, unless conveyed within a metal pipe or other suitable casing, be kept well apart both within and without the enclosure and shall run so that the course of each may be readily traced.

(*c.*) Cables for cinematograph lamps shall be taken as separate circuits from the source of supply and from the supply side of the main fuses in the general lighting circuit, and there shall be efficient switches and fuses inserted at the point where the supply is taken, and in addition, an efficient double-pole switch shall be fitted in the cinematograph lamp circuit inside the enclosure. When the cinematograph lamp is working, the pressure of the current across the terminals of the double-pole switch inside the enclosure shall not exceed 110 volts.

(*d.*) Resistances shall be made entirely of fire-resisting material, and shall be so constructed and maintained that no coil or other part shall at any time become unduly heated.* All resistances, with the exception of

* *e.g., they should not become so heated that a piece of newspaper placed in contact with any part of the resistance would readily ignite.*

a resistance for regulating purposes, shall be placed outside the enclosure and, if reasonably practicable, outside the auditorium. If inside the auditorium, they shall be adequately protected by a wire guard or other efficient means of preventing accidental contact.

The operator shall satisfy himself before the commencement of each performance that all cables, leads, connections, and resistances are in proper working order. The resistances, if not under constant observation, shall be inspected at least once during each performance. If any fault is detected, current shall be immediately switched off, and shall remain switched off until the fault has been remedied.

Limelight.

13.—(*a*.) If limelight be used in the lantern the gas cylinders shall be tested and filled in conformity with the requirements set out in the Appendix hereto. The tubing shall be of sufficient strength to resist pressure from without and shall be properly connected up.

(*b*.) No gas shall be stored or used save in containers constructed in accordance with the requirements contained in the Appendix.

LICENCES.

14. Every licence granted under the Act shall contain specific conditions for the carrying out of regulations 2 and 5 (1) (*a*), (*b*), (*c*), (*d*), (*e*), (*f*) in the building for which the licence is granted, and may, in accordance with regulation 5 (2), contain an expression of opinion on the matters referred to in the proviso thereto.

15. Subject to the provisions of No. 16 of these regulations, every licence granted under the Act shall contain a clause providing for its lapse, or, alternatively, for its revocation by the licensing authority, if any alteration is made in the building or the enclosure without the sanction of the said authority.

16. Where a licence has been granted under the Act in respect of a movable building, a plan and description of the building, certified with the approval of the licensing authority, shall be attached to the licence. Such a licence may provide that any of the conditions or restrictions contained therein may be modified either by the licensing authority or by the licensing authority of the district where an exhibition is about to be given. The licence and plan and description or any of them shall be produced on demand to any police constable or to any person authorised by the licensing authority or by the authority in whose district the building is being or is about to be used for the purpose of an exhibition.

17. The regulations dated December 20th, 1909, made under the Cinematograph Act, 1909, are hereby repealed, provided, nevertheless, that any licence granted prior to such repeal shall remain valid for the period for which it was granted without the imposition of any more stringent condition than may have been imposed at the time of the grant.

APPENDIX TO STATUTORY RULES AND ORDERS.

LIMELIGHT.

The gas cylinders shall be tested and filled in conformity with the requirements set out below, which follow the recommendations of the

Departmental Committee of the Home Office on the Manufacture of Compressed Gas Cylinders [C. 7952 of 1896]. (*Also approved by the London County Council, Jan.* 25, 1898):—

Cylinders of Compressed Gas (Oxygen, Hydrogen, or Coal Gas).

(*a*) *Lap-welded wrought iron.*—Greatest working pressure, 120 atmospheres, or 1,800 lbs. per square inch.

Stress due to working pressure not to exceed 6½ tons per square inch.

Proof pressure in hydraulic test, after annealing, 224 atmospheres, or 3,360 lbs. per square inch.

Permanent stretch in hydraulic test not to exceed 10 per cent. of the elastic stretch.

One cylinder in 50 to be subjected to a statical bending test, and to stand crushing nearly flat between two rounded knife-edges without cracking.

(*b*) *Lap-welded or seamless steel.*—Greatest working pressure, 120 atmospheres, or 1,800 lbs. per square inch.

Stress due to working pressure not to exceed 7½ tons per square inch in lap-welded, or 8 tons per square inch in seamless cylinders.

Carbon in steel not to exceed 0.25 per cent. or iron to be less than 99 per cent.

Tenacity of steel not to be less than 26 or more than 33 tons per square inch. Ultimate elongation not less than 1.2 inches in 8 inches. Test-bar to be cut from finished annealed cylinder.

Proof pressure in hydraulic test, after annealing, 224 atmospheres, or 3,360 lbs. per square inch.

Permanent stretch shown by water jacket not to exceed 10 per cent. of elastic stretch.

One cylinder in 50 to be subjected to a statical bending test, and to stand crushing nearly flat between rounded knife-edges without cracking.

Regulations applicable to all Cylinders.

Cylinders to be marked with a rotation number, a manufacturer's or owner's mark, an annealing mark with date, a test mark with date. The marks to be permanent and easily visible.

Testing to be repeated at least every two years, and annealing at least every four years.

A record to be kept of all tests.

Cylinders which fail in testing to be destroyed or rendered useless.

Hydrogen and coal gas cylinders to have left-handed threads for attaching connections and to be painted red.

The compressing apparatus to have two pressure gauges, and an automatic arrangement for preventing overcharging. The compressing apparatus for oxygen to be wholly distinct and unconnected with the compressing apparatus for hydrogen and coal gas.

Cylinders not to be refilled till they have been emptied.

If cylinders are sent out unpacked the valve fittings should be protected by a steel cap.

A minimum weight to be fixed for each size of cylinder in accordance with its required thickness. Cylinders of less weight to be rejected.

L.C.C. REGULATIONS RESPECTING THE USE OF CINEMATOGRAPH APPARATUS, ETC., IN THEATRES, AND OTHER PREMISES LICENSED BY THE COUNCIL. (*Approved by the Council, April 6th,* 1909.)

(1) No cinematograph, or other similar apparatus involving the use of a combustible film, shall be exhibited on premises licensed by the Council until the Council has been satisfied that all reasonable precautions have been taken against accidents and danger to the public.

(2) Where cinematograph displays do not form a regular feature of the entertainment, notice of any intended exhibition shall be given to the Clerk of the Council by the licensee of the premises in which such exhibition is to be given, and such notice shall be given at least three days before the exhibition takes place. Opportunity shall also be afforded to the Council's inspector of inspecting the apparatus at least four hours before the public exhibition takes place, in order to allow time for any necessary alterations to be carried out and approved by the Council's inspector.

(3) In no circumstances shall a cinematograph chamber be placed so as to interfere with the free use of an exit-way, and any temporary alteration in the regular line of a gangway must be amply compensated for by the re-arrangement or removal of seats.

(4) Where cinematograph displays form a regular feature of the entertainment, the apparatus shall be placed in a permanent enclosure of sufficient dimensions to allow the operator to work freely. Such enclosure shall be constructed of solid incombustible materials not less than 3 inches thick and be provided with a proper ventilating trunk carried from the highest point of the interior of the enclosure to the outside air. The entrance to the enclosure shall be fitted with a self-closing, fire-resisting and smoke-proof door placed at the rear, or on the operating side of the apparatus, and opening outwards.

Where cinematograph displays are occasionally included in the programme, the lantern shall, if a permanent enclosure be not available, be contained in a smoke-proof box constructed of sheet iron on substantial framework and fastened together securely. The box shall be of sufficient dimensions to allow the operator to work freely and the floor shall, if boarded, be covered with asbestos or other fire-resisting material. Such enclosure shall, wherever practicable, be ventilated direct to the outside air, and the entrance door thereto shall be self-closing and smoke-proof.

Openings not larger than is necessary for effective projection, and not exceeding in number two for each lantern, shall be permitted in the front face of the enclosure. The openings shall be fitted with a fire-resisting screen or screens, which on being released from either the inside or the outside of the enclosure shall close automatically with a smoke-proof joint.

The necessary pipes, electric cables, etc., shall enter the enclosure through properly bushed openings.

(5) The lantern shall be placed on firm supports of fire-resisting construction. The lamp or jet shall stand on an iron tray, with a vertical edge at least 1 inch in depth. The lantern shall be provided with a metal shutter which can be readily inserted between the source of light and the film gate.

The film gate shall be of massive construction, and provided with ample heat radiating surface, and the passage for the film shall be sufficiently narrow to prevent flame travelling upwards or downwards from the light opening.

(6) Where possible, the electric arc light shall be adopted as the illuminant, the Council's regulations for securing safety in an electrical installation being observed. Circuits in which there is a pressure exceeding 250 volts between the poles or from either pole to earth, shall not be allowed in connection with the apparatus. Where the apparatus is used in a portable box a permanently installed circuit shall be carried to a convenient point having regard to the usual position of the apparatus. Resistances shall be fixed in approved positions and, where practicable, outside the enclosure. A small resistance for regulating purposes will, if desired, be allowed within the enclosure, but such resistance shall be fixed above the level of, and behind the lantern.

All live terminals and fittings shall, as far as practicable, be protected so as to minimise the risk of short circuit or shock. Suitable fuses shall be provided at each pole for the main circuit and for each of the sub-circuits, e.g. the sub-circuits for pilot lights.

If limelight be used in the lantern the general regulations for its safety, which are issued by the Council, shall be complied with, special attention being given to the tubing, which shall be of sufficient strength to resist pressure from without, and shall be properly connected up. Ether and other inflammable liquids shall not be employed under any circumstances for producing light.

(7) All cinematograph projectors shall be fitted with two metal film boxes of substantial construction, and not more than 12 inches in diameter, inside measurement, to and from which the film shall travel. Such boxes shall be made to close in a manner which will prevent the ingress of fire, and shall be fitted with a film slot capable of preventing the passage of flame to the interior of the film box. Gearing should be used in preference to flexible belts for driving the "take-up" spool.

All films when not in the machine, and while still in the operating enclosure, shall be contained in such closed metal boxes.

(8) (*a*) Smoking within the enclosure shall be forbidden at all times.

(*b*) Storage of any description shall not be permitted within the enclosure.

(*c*) Adequate small fire appliances, including a bucket of sand, shall be kept available outside the enclosure and be in the charge of a special attendant.

(*d*) The general lighting of the hall and exits shall not be controlled solely from within the operating enclosure.

(*e*) A suitable barrier shall be placed round the temporary box to prevent the audience coming into contact therewith.

(9) The licensee shall be held responsible for seeing that the Council's regulations are complied with in every respect, and for the employment of competent, experienced and trustworthy operators, and shall be prepared at any time to supply to the Council satisfactory credentials in this respect.

(10) The Council reserves to itself the right of requiring the adoption of any further precautions, in addition to those specified above, as circumstances may require.

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